Original Article

A Revised Measure of Acute Pain in Infants

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Abstract

Acute pain in infants is not assessed or managed optimally. The objectives of the study were (a) to adapt a behavioral pain assessment measure (Children's Hospital of Eastern Ontario Pain Scale, CHEOPS) for use with infants, and (b) to establish the reliability and validity of the measure in a study of infants undergoing immunization. Ninety-six healthy 4- to 6-month-old infants were randomized to receive either the local anesthetic cream Eutectic Mixture of Local Anesthetics (EMLA) (N = 49), or a placebo (N = 47) prior to immunization. The infant's behavioral response was videotaped immediately before and following the immunization. Postprocedural pain scores were assessed from the videotape and were significantly lower in infants who received EMLA (P = 0.01). Pain scores were also significantly correlated with visual analogue scale (VAS) scores assessed during vaccination. Five independent raters also independently rated ten infants to determine interrater reliability. Agreement between raters' scores was high (intraclass correlation coefficient, 0.95). Results from this study suggest that this measure has beginning construct and concurrent validity and interrater reliability when used in a research study. Further testing of the measure in the clinical setting is required. J Pain Symptom Manage *1995;10:456–463.*

Key Words

Infant, pain assessment, pain scale, pain tool, pain behavior, immunization

Introduction

The assessment of acute iatrogenic pain in infants is problematic because pain is difficult to identify and quantify. In the case of older children, assessment tools such as the Oucher,[1] Analogue Chromatic Continuous Scale (ACCS),[2] Poker Chip Tool,[3] or visual analogue scale (VAS) can be directly administered, so that the child can provide information about his/her own pain. In infants, however, one must rely solely on the assessment made by others who have interpreted the painful event. The objective of this study was to develop a clinically applicable pain measure for young infants. To accomplish this objective, we modified an existing pain measure, and tested its reliability and validity in infants receiving routine immunizations. This study was part of a larger clinical trial, in which we tested the efficacy of a local anesthetic compared to a placebo in decreasing infant pain from vaccination.[4]

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Review of Pain Assessment in Young Infants

Infant facial expressions have been extensively investigated as a measure of pain. Izard[5] developed a coding system that classifies observed reactions according to emotional state (Maximally Discriminative Facial Movement Coding System, MAX). Videotapes of infants are taken and subsequently reviewed by trained raters for the presence or absence of designated facial movements in three areas: brow, eyes, and mouth. Facial expressions are then categorized according to emotional state.[6] The characteristics of pain include: lowered and drawn together brow, nasal root widening and bulging, eyes tightly closed, and angular, squarish mouth.

Grunau and Craig developed the Neonatal Facial Coding System (NFCS).[7] Like the MAX, the NFCS uses facial actions to describe infant responses. Unlike the MAX, however, there is no attempt to describe emotional states. Infants are scored on the presence or absence of the following facial actions: brow bulge, eye squeeze, nasolabial furrow, open lips, vertical stretch mouth, horizontal stretch mouth, lip purse, taut tongue, chin quiver, and tongue protrusion. The amount of infant facial action has been shown to vary with the nature of the medical procedure (that is, invasive or noninvasive).[8] In addition, facial activity scores have been shown to relate to parental pain ratings, providing external validation of this method to characterize neonatal pain.[9] Despite these attributes, like the MAX, the NFCS is a labor-intensive scoring system. Infant facial actions are scored on a per-second basis by trained coders who view videotapes of painful situations.

Infant vocalizations have also been used to describe pain.[8,10-12] Cry characteristics included in pain assessments are latency to cry, duration of first cry cycle, frequency of cry, intensity, melody, jitter, and dysphonia. Spectrographic analyses have demonstrated differences between pain cries and other cries, although the cry sounds from painful situations are not uniquely different from those of other types of cries.[13-15] As a single measure of pain, cry is insufficient because it is not consistently observed in all infants.

Observations of infant body movements have also been used by investigators to determine pain. Infants react to acute noxious stimuli by thrashing, jerking, wiggling, withdrawing, kicking, or exhibiting torso rigidity.[16-21] Craig and colleagues[22] developed the Infant Body Coding System (IBCS) in order to capture neonatal body activity. The IBCS is used in a similar fashion as the NFCS; trained coders score the presence or absence of hand, foot, arm, leg, head, and torso movements.

In addition to the behavioral approaches described above, physiological indicators have also been observed during painful situations.[10,16,22-30] Marked increases in respiration rate, heart rate, blood pressure, and cortisol levels have been demonstrated after infant exposure to a noxious stimulus. Conversely, oxygen saturation has been observed to decrease. Levels of adrenaline, beta-endorphin, insulin, and glucagon are particularly useful as indices of surgical stress.[31-33] Physiologic changes provide objective pain measures, however, they are not specific to pain.[34] Observations are difficult to interpret[7] in situations where there are technical problems. In fact, application of the monitor on the very young infant may modulate the infant's response.

To summarize, infant pain responses have been demonstrated to encompass a variety of dimensions including facial action, crying, body movements, and physiologic changes. The specificity of each dimension to pain is not known, but appears to be highest for facial reactions and lowest for physiologic measures. At present, it is uncertain whether any one dimension sufficiently approximates the infant's pain. As a consequence, currently available infant pain assessment scales include more than one dimension to facilitate a more complete description. The multidimensional approach is believed to improve the validity of the pain assessment. There is a risk, however, of including redundant variables in the measure.

The inter-relationships between constituent items should be carefully scrutinized during the development stages of a tool for infant pain assessment. In general, infant pain assessment scales have concentrated on behavioral responses; namely, facial, cry and body behaviors[35,36] due to the frequency of occurrence of these reactions and the ease with which they are observed. A review of some pain measures developed for infants is provided below.

Barrier and colleagues[37] developed a postoperative pain scale to demonstrate the efficacy of an analgesic in infants. The pain scale utilized assessments of infant sleep, facial expression, cry quality, motor activity, responsiveness to stimulation, limb flexion activity, sucking, tone, consolability, and sociability. Although simpler to use than facial coding systems such as the NFCS, this scoring system requires observation of the infant over the preceding hour, which is not always feasible. Recently, Buchholz and colleagues[38] compared the scores obtained with that scale with those of VAS in infants undergoing surgery. The observation of the infant for the preceding hour was omitted. There was a statistically significant correlation in pain scores between the two measures. Pokela[39] developed a behavioral pain measure for measuring the pain in mechanically ventilated neonates. The instrument measured pain from four behaviors; infant facial expression, movements, response to handling, and rigidity of the limbs. The measure successfully demonstrated that opioid therapy resulted in less pain during a medical procedure than treatment with saline.

Fradet and colleagues[40] and McGrath and colleagues[41] developed the Children's Hospital of Eastern Ontario Pain Scale (CHEOPS), which has been used to measure postoperative, venipuncture, or fingerprick pain in children greater than 3 years of age. The CHEOPS scores pain across six categories: cry, facial expression, verbal expression, torso activity, touch, and leg activity. A numerical score is assigned to each activity, and the total score is the sum of the individual scores. The CHEOPS has been internally validated, and correlated with other pain measurement scores.

The CHEOPS was adapted by Robieux and colleagues[42] in a clinical trial to measure pain from venipuncture in infants aged 3–36 months. Infants were premedicated with either the local anesthetic Eutectic Mixture of Local Anesthetics; lidocaine, and prilocaine (EMLA) or placebo prior to venipuncture. The tool, herein entitled the Behavioral Pain Score (BPS), scores pain from facial expression, cry, and body movements. Congruent with the expectation that analgesia reduces pain intensity, the BPS pain scores in infants treated with EMLA were lower than those of infants given placebo. The limitation of the BPS is that it was developed for use in older infants and may not adequately describe the variability of the responses in younger infants.

Lawrence and colleagues[43] recently modified the CHEOPS for use in neonates. The Neonatal Infant Pain Scale (NIPS) was designed to measure pain in the neonatal intensive care unit (NICU). Pain is scored from six items; facial expression, cry, breathing patterns, arm and leg activity, and state of arousal. The NIPS was shown to have good interrater reliability and beginning construct validity. To date, it has been validated on a small number of neonates and only for research purposes. Other pain measures have recently been developed and are in the process of being validated.[44–46]

Objectives

During the time we undertook this trial, a validated and clinically useful measure was not available to assess pain in infants. The objectives of this study were to (a) modify a pain tool (that is, the BPS), for use in infants aged 2–6 months; (b) establish concurrent validity, construct validity, and internal consistency of the new measure; and (c) demonstrate interrater agreement and test–retest reliability of the new measure.

Methods

Development of the Pain Assessment Measure

The study was approved by our hospital's Research Ethics Committee. Consent was obtained from a convenience sample of parents to videotape their infants during routine vaccination in a metropolitan outpatient pediatric clinic. These videotapes were used to develop and validate the pain measure (herein called the Modified Behavioral Pain Scale, or MBPS). During a pilot study, five raters (neurologist, pediatrician, pharmacist, physiotherapist, and lay person), simultaneously viewed 11 videotaped immunizations in infants aged 9 weeks to 5 months, and collectively assessed infants' pain using the BPS scale (Table 1). Raters made two pain assessments for each vaccination session; the first was a baseline

Table 1
Behavioral Pain Score

Observed behavior	Score (total 0–8)
Facial expression	
Positive (smiling)	0
Neutral	1
Negative (grimace)	2
Cry	
Laughing or giggling	0
Not crying	1
Moaning	2
Full lunged cry or sobbing	3
Movements	
Usual activities (that is, playing)	0
Neutral, not moving	1
Attempt to withdraw limb	2
Complex agitation involving head, other limbs	3

From reference no. 42

BPS pain assessment within 5 sec before the immunization, and the second was a postvaccination BPS assessment, made 15 sec after the immunization. The baseline pain score was defined as the reaction observed in the infant for the majority of the time during the 5-sec observation period. The postvaccination pain score was defined as the maximum reaction observed in the infant during the 15 second observation period. The BPS assessments made after each vaccination were discussed by the raters, and the new tool (MBPS, Table 2) was developed. The changes made to the pain scale were reviewed by a psychologist familiar with pediatric pain assessment tool development. The scoring system of the tool was altered to maximize changes between baseline and postvaccination pain scores. The minimum score that could be obtained on the MBPS was 0 and the maximum 10.

Subjects

The reliability and validity of the MBPS was tested on 4- to 6-month-old infants who participated in a randomized, double-blind clinical trial in which we assessed the efficacy of EMLA in decreasing pain from diphtheria-pertussis-tetanus (DPT) vaccine. Infants were premedicated with either EMLA or placebo for 60–90 min prior to vaccination, and immunizations were administered by one of two pediatricians who participated in the study. Injections were performed in a similar fashion (that is, infants were placed in a supine position on the examining table, and 0.5 mL of injectate was administered intramuscularly in the lateral upper thigh region). The full body of the infant was videotaped by a videographer who stood approximately 3 feet away from the infant, prior to, during, and after the vaccination until the baby settled. A mirror was mounted on the wall adjacent to the examining table to enable the videographer to tape the baby's reaction as observed through the mirror image as well as face on. This method of videotaping was used because prior observations revealed that infants often turned their heads from side to side during immunization. Altogether, 96 infants were evaluable for analyses; 49 received EMLA, and 47 placebo. The mean age of the infants was 5 months, and the male-to-female ratio was 1:1. There were no statistically significant differences between the treatment groups in demographic characteristics of age, sex, or weight.

Validity of the MBPS

During the clinical trial, a trained observer rated infant pain immediately after the vaccination using a 100-mm ungraded visual analogue scale (VAS) ruler, where 0 mm denoted no pain and 100 mm denoted worst possible pain. The pediatrician who administered the vaccine also rated infant pain using a VAS. As two pediatricians participated in the study, each rated approximately one-half of the sample. One coder viewed the videotapes at a later time and assessed infant pain using the MBPS. The MBPS was scored in a similar fashion as the BPS. Postvaccination MBPS pain scores were correlated with the VAS pain scores to establish concurrent validity.

To establish construct validity of the MBPS, scores were compared between infants who received the anesthetic EMLA and those who received placebo. A lower pain score in the EMLA group would be congruent with our assumption that analgesia reduces pain.[47]

Reliability of the MBPS

In order to test internal consistency of the tool, the postvaccination MBPS scores obtained on the different items of the tool were correlated. Item-total correlations were also performed between the individual items with the scale total after omitting that item.

Interrater agreement was tested with the scores from five raters who viewed the immu-

Table 2
Modified Behavioral Pain Scale (MBPS)

Observed behavior	Score (0–10)	Operational definitions
Facial expression		
Definite positive expression	0	smiling
Neutral expression	1	
Slightly negative expression: for example, grimace	2	brow bulge, naso-labial furrow
Definite negative expression: that is, furrowed brows, eyes closed tightly	3	brow bulge, naso-labial furrow, eyes closed tight, open lips; with or without reddened face
Cry		
Laughing or giggling	0	
Not crying	1	
Moaning, quiet vocalizing, gentle or whimpering cry	2	
Full lunged cry or sobbing	3	
Full lunged cry, more than baseline cry	4	to be scored only if infant crying during baseline
Movements		
Usual movements/activity, or resting/relaxed	0	
Partial movement or attempt to avoid pain by withdrawing the limb where puncture is done	2	squirming, arching, limb tensing/clenching
Agitation with complex movements involving the head, torso, or the other limbs, or rigidity	3	generalized limb and/or body movements, or rigidity

nizations of a subsample of ten infants who participated in the clinical trial. The mean infant age was 5.3 months; five were male. The raters independently scored baseline pain (5 sec before the injection) and postvaccination pain (15 sec after the injection) for each vaccination. Thus, each rater made 20 pain assessments that were used in the analysis of interrater reliability.

To assess whether MBPS scores obtained from the raters were stable, one of the raters assessed pain from the same infants after 12 months (test–retest reliability).

Data Analysis

The agreement between the raters' scores were assessed using the intraclass correlation coefficient (ICC) as described by Streiner and Norman[48] using a one-factor analysis of variance (ANOVA).[49] An acceptable level of interobserver agreement was deemed to be greater than 0.75.[50] Correlations between scores were measured using Pearson's correlation coefficient. The a priori significance level was $P < 0.05$.

Results Validity

Concurrent validity. Postvaccination MBPS scores were positively correlated with observer and pediatrician VAS scores. The correlation coefficient between MBPS and observer VAS scores was 0.68 ($P < 0.001$). The correlation coefficient between MBPS and pediatrician VAS scores was 0.74 ($P < 0.001$).

Construct validity. Baseline MBPS scores (mean, 1.9; SD, 0.8) were significantly lower than postvaccination scores (mean, 7.3; SD, 1.8); $P < 0.01$. When infants were stratified by group assignment (that is, EMLA or placebo), baseline MBPS scores were not different between groups ($P < 0.72$). Postvaccination MBPS scores, however, were significantly lower for the EMLA group (mean, 6.8; SD, 1.9) compared to the placebo group (mean, 8; SD, 1.5); $P < 0.01$.

Reliability

Internal consistency of items. The postvaccination pain scores obtained from each category of the MBPS (that is, face, cry, and movement) were correlated. Facial action scores significantly correlated with cry ($r = 0.67$, $P < 0.001$). Body movement scores also correlated with cry ($r = 0.48$, $P < 0.001$) and facial action ($r = 0.54$, $P < 0.001$). Item-total correlations between each item and postvaccination MBPS scores without that item produced coefficients of 0.66 ($P < 0.001$) for face, 0.55 ($P < 0.001$) for body movement, and 0.60 ($P < 0.001$) for cry.

Interrater agreement. The ANOVA analysis of the five raters' assessments showed very high agreement in the scores (ICC = 0.95, $P < 0.001$). Systematic bias was not observed between raters ($P = 0.13$), indicating that no rater was scoring consistently higher or lower than the others. The ICCs calculated on the three categories of the MBPS also showed high agreement: 0.89 ($P < 0.001$) for facial movement, 0.96 ($P < 0.001$) for infant cry, and 0.83 ($P < 0.001$) for body movements.

Test–retest reliability. The correlation between the rater's scores of the same cases revealed consistency in assessments over time ($r = 0.95$, $P < 0.001$).

Discussion

Immunizations are the most common source of acute pain in healthy infants. Nevertheless, analgesics have not been routinely administered. The lack of vaccination pain management may partly be due to inadequately tested and/or feasible pain assessment tools. We modified an existing behavioral pain scale to measure pain in young infants receiving routine immunizations; and to test the effect of a local anesthetic on infant immunization pain. The pain scores derived from the modified measure (that is, MBPS) correlated with observer and pediatrician VAS scores, providing convergent validity for the scale. The MBPS scores were significantly higher in infants given placebo compared to EMLA, providing evidence for construct validity.

The results are congruent with the pharmacology of EMLA, namely, that it causes skin anesthesia. It is interesting to note that infants in both groups scored near the high end of the scale, suggesting that there was pain in both groups. As EMLA only penetrates up to approximately 5 mm under the skin,[51] and the vaccination is administered into the infant'smuscle, it follows that, although EMLA modulates the pain response from the needle prick, it probably does not prevent the pain from the administration of the vaccine, nor of the vaccine itself. Future research should investigate the effect of EMLA in combination with other pain-reducing interventions.

The MBPS was developed as a practical measure that could be easily utilized to assess acute pain in a clinical setting. A multi-item scoring system was used, as no single behavior is believed to adequately reflect infant pain.[52] Internal consistency in scoring of the elements of the scale revealed significant, but only modest correlation coefficients. These results substantiate the notion that the scale is tapping different aspects of the same attribute, presumably pain. Each item correlated with the total pain score minus that item with coefficients greater than 0.50. A generally accepted value is a correlation coefficient greater than 0.20.

The MBPS was designed and used to measure pain in infants of varying ages (that is, 2–6 months). Previous researchers have demonstrated that behavioral responses are relatively consistent in infants 4–6 months of age.[53,54] Older infants[20,55] exhibit a shorter duration of pain expression and less symmetrical movement.

Reliability testing demonstrated very high agreement among the raters' scores of the same vaccination episodes. Interrater agreement, however, was assessed using the same five raters that developed the scale. Further investigations of scoring consistency with different raters will be necessary to confirm these results. As the measure was used in a research setting, it requires validation in clinical practice. Finally, as the data are limited to healthy young infants and routine DPT vaccination, the MBPS requires testing in other age groups and in other procedures to demonstrate generalizability.

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