Psychophysical scaling in pain in newborns: component comparison analysis

Rosana Maria Tristão[1]
Naiara Viudes Martins Garcia[1]
José Alfredo Lacerda de Jesus[1]
Carlos Tomaz[2]

Faculty of Medicine[1] and Institute of Biology[2], Campus Darcy Ribeiro, Universidade de Brasília, DF, Brazil

Corresponding Author: RM Tristão (rmtt@unb.br)

Abstract

COMFORT behavior scale (Cb) has been applied in neonatal units to measure pain in newborns. This study aimed to analyze parameter´s scale testing if they differ in sensibility to pain. The scores were correlated to skin conductance activity (SCA). Thirty-six newborns were videotaped whilst heel prick. The images were analyzed in three intervals: before, during and after the pain event. Cb scale scores were compared to SCA variables: number of waves/sec and area under curves in three different time intervals after the pain event: 15, 30 and 180sec. All factors of Cb were sensitive to changes among periods during-before and after-during. Significant correlations values were found between Cb and number of waves (r < 0.6). Facial Tension was the gold standard response to pain meanwhile factors as Crying and Calmness can be considered poor indicators of pain. These results are discussed in terms of phenomenological approach and anxiety paradigm.

Keyword: COMFORT behavior scale, pain, neonates, skin conductance activity, anxiety.

Introduction

The evaluation and scaling of pain perception are fundamentally related to the clinical art dependent on patient's report, behavioral observation and physiological measures based on physical examination. Newborns follow these parameters except the ability to report what they perceive. Although the statement that newborns are able to perceive pain was controversial for many decades, nowadays there are enough evidence that they are capable of perceive and report pain both on their medical condition or clinical procedures performed as collection of blood, endotracheal suction, surgery or other invasive procedures (Harrison *et al.*, 2006). Pain is defined by the International Association for the Study of Pain (IASP) as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage" (Merskey H. Bogduk, 1994; IASP Task Force on Taxonomy, 1994, updated 2011). This definition has been often used in studies about pain despite theoretical models or kind of subject, but this worldwide use can´t prevent or hidden the truth of how difficult is to define pain, specially the pain perceived by non-verbal subjects. To assess pain in infants, behavioral and physiological parameters were designed to reduce the subjectivity linked to patient response and give more subsides for research in neonates who do not report the pain (Eriksson *et al*., 2008; Storm, 2008). Several pain scales have been introduced, either unidimensional or multidimensional which combines behavioral and physiological dimensions of pain (de Oliveira *et al.*, 2010) such as COMFORT scale (Ambuel *et al.,* 1992; van Dijk *et al.,* 2005), *Neonatal Infant Pain Scale* (Lawrence *et al.,* 1993), *Neonatal Facial Coding System* (Grunau & Craig, 1987) and *Neonatal Pain, Agitation and Sedation Scale* (Hummel *et al.,* 2008, Hummel *et al.,* 2010) among others.

Despite the crescent pool of validated pain scales for infants, the physiological parameters as heart rate (Pereira *et al.,* 1999, Padhye *et al.,* 2009, Jesus *et al.*, 2011), blood pressure, oxygen saturation (Hummel & van Dijk, 2006, Jesus *et al.*, 2011) have attended to assess pain and validate other instruments in newborns. Skin conductance activity (SCA) (Storm, 2000; Storm & Freming, 2002, Gjerstad *et al.,* 2008) also has been used as a measure of pain specially in monitoring context of infants under sedation or anesthetized (Eriksson *et al*., 2008; Storm, 2001; Hullett *et al*., 2009, Jesus *et al.*, 2011; de Oliveira *et al*., 2012). This type of sweat is dependent on the response of the cerebral cortex through the activation of the sympathetic nervous system (SNS) on the sweat glands, and regardless of weather or cardio respiratory conditions (Storm, 2001; Harrison *et al*., 2006; Storm, 2008).

Previous study has already compared skin conductance to the scores of the COMFORT scale and COMFORT behavior scale. Gjerstad, Wagner, Henrichsen & Storm (2008) analyzed skin conductance fluctuations during endotracheal suctioning and they founded better correlation with the increase in the COMFORT scale score than the variation of heart rate and arterial blood pressure. Considering that the skin conductance is the fastest measurement system of all, giving pain perception measurement in short intervals as 15 seconds, one possible question raised from these results is whether some dimensions of the COMFORT behavior scale are as sensitive and fast in revealing infant´s pain perception. If it is so, it can be used as alert signals to clinical teams in emergency contexts or limited contexts for use pain scales or the skin conductance device, a common situation in ICU's context. van Dijk adapted and modified this scale cutting off these physiological variables and created a COMFORT behaviour scale which uses only the behaviour and the phenomenological dimensions (van Djik *et al.,* 2005). This phenomenological dimension is linked to the behavioral one, and consists of at least two sub-dimensions, sensory-discriminative and affective-emotional (experience's spontaneous cognitive/conative reactions to own pain experiences). According to Aydede *et al.,* 2010 it means that "These reactions were conceived as forming *conative propositional attitudes*. In other words, the painfulness of pains was constituted by their power to immediately evoke in [one] the peremptory desire that the [pain] perception should cease". The sensory-discriminative aspect of pain is representational: it represents tissue damage. To define the phenomenological aspect is very difficult, but it can be said that feeling pain involves perception although perception doesn't exhaust its nature: feeling pain is also an affective/emotional experience that can be explained in terms of the functional role of pain's sensory/representational content.

Taking into account the above mentioned aspects, this study aims to compare all COMFORT behavior scale´s dimensions and its behavioral indicators to the physiological measurement of pain by skin conductance to test the sensibility and specificity of each scale´s item. Hence, this study assessed whether each variable in the COMFORT behavior scale can be used independently as a measure predictor of pain in newborns. To assess each variable of COMFORT behavior scale we used the validated equipment for measuring pain in neonates, Skin Conductance Measurement System (SCMS®), as a comparative method of results analysis (Harrison, 2006) in three different time windows to verify the efficacy of each item of the scale. We hypothesized that the best correlations between behavioral and physiological indicators would reveal the most efficient responses of neonates to be used in future studies about acute pain in infants and the most effective response to be considered for clinical and research purposes.

Methods

Subjects

Were selected 36 newborns, 19 males and 17 females, with gestational age between 37 to 41 weeks (mean = 38,95 weeks; ± 1,35 weeks) with up to 48 hours of life at the Maternity of the University of Brasília Hospital. These babies were subjected to routine procedure in the ICU such as daily assessment of glucose by heel prick. Parents of infants were consulted and informed about the purpose of the study by signing the consent form. Were excluded from the sample infants with postnatal age less than 24 hours, with Apgar score less than seven in the fifth minute of life with a diagnosis of intracranial hemorrhage in the third or fourth degree (Volpe 2008); with metabolic, respiratory, circulatory, congenital disorders; and has used drugs that interfere with the perception of pain (analgesics, sedatives or muscle relaxants), neonates whose mothers used opioid and/or its derivatives during pregnancy.

Procedure, Apparatus and COMFORT Behavior Scale

The infants' responses were videotaped using a camcorder (DCR-SR 47, Sony), SCA was measured by the Skin Conductance Measurement System (SCMS®, Medstorm Innovation) through three established conductance variables: basal level of conductance peaks, number of waves per second (NWps) and area under the curve of waves (AUC). COMFORT behavior scale (C*b*) was used to assess the following variables: muscle tone, facial expression, alertness, calmness/agitation, respiratory pattern and physical movement. Each variable has a range of five points, obtaining a total sum of six behavioral variables. Thus, one can obtain six as lower value reflecting the minimum degree of discomfort and a maximum of 30 points (van Djik *et al.,* 2005).

To evaluate the behavioral response to noxious stimulus, the neonates were submitted to their daily routine heel prick for glucose monitoring. The exams were done early morning, at their bed and by the same examiner. The three electrodes of the equipment were attached and wrapped to the left foot 10 min before starting the observation period. The skin conductance measures were taken at three time intervals after the heel prick: 15, 30 and 180sec. All variables were analyzed in three periods "before" "during" and "after" the procedure. One trained observer assessed the movies and scored the infant´s behaviors by Cb. The SCA parameters were taken from the SCMS® software register system for three minutes.

Statistics

Each item's score of Cb was compared between the periods "before", "during" and "after" the procedure by the paired-related sample when comparing the differences *during-before*. The Wilcoxon nonparametric-paired test was used to analyze the significant difference of the change in scores along the studied periods. To assess the global score of Cb, as well as their variables, were compared to SCA by the Spearman's bivariate correlation. To verify if the clinical and demographic were related, it was used GLM two-way ANCOVA analyses. Analyses of agreement between Cb scores and subscores and skin conductance variables, all them calculated as difference between during-after pain periods, was made using Kendall's coefficient of concordance. Kolmogorov-Smirnov's normality test was passed for all data sets ($p > 0.05$) and the Levene's test of homogeneous variances was not significant for all analyses ($p > 0.05$). The data was stored on computer and analyzed using SPSS Package Version 17.0 and Minitab® 15.1.30.0.

Results

The sample variables had a mean gestational age of 38.9 weeks; 68,3% were delivered by cesarean section; 39% were large for gestational age; 41,5% small for date and 5,1% from diabetic mothers; 68% were breastfed one hour before the procedure. The paired-sample test of each variable of Cb showed significance for all variables both the period during–before and after–during (Table 1). All variables were statistically significance $p < 0,001$. According to the Spearman's bivariate correlation (Table 2) between each variable of Cb and SCA considering NWps after the procedure (15sec, 30sec and 180sec) all of them were significant ($p < 0.05$) but showed from fair to moderate correlations ($r < 0,6$). Crying and calmness were the weakest factors to all time windows (Table 2). Only physical movement and facial expression showed a significant correlation between AUC 15sec and 30sec after the procedure, but all of them showed from fair to moderate correlations ($r < 0,6$). Global score of the Cb was compared with the SCA by Spearman's Bivariate Correlation in each period of analysis. Were not found statistically significance between the score of the scale before and during the procedure (heel prick) with the NWps (15sec, 30sec, 180sec) and AUC (15sec, 30sec, 180sec). The Cb score after the heel prick was statistically significant ($p < 0,005$) for the NWps (15sec, 30sec, 180sec), but the highest correlation was to NWps 180sec ($r = 0,504$, $p < 0,001$).

Table 1. Paired-samples test of each variable of Cb in the 37 neonates.

Pair	During -before	After -during
Cb	-4,956**	-5,450**
Alertness	-4,057**	-3,849**
Calmness	-4,965**	-4,096**
Crying	-5,597**	-5,412**

Physical Movement	-4,818**	-4,757**
Muscle Tone	-4,954**	-4,789**
Facial Tension	-5,241**	-5,179**

Notes: Wilcoxon test ** $p < 0.01$;

Table 2. Spearman's Bivariate Correlation between each variable of Cb and SCA considering 15, 30 and 180 sec after the procedure (heel prick).

Variables	15sec	30sec	180sec
Cb and NWps	0,424**	0,383*	0,504**
Alertness and NWps	0,576**	0,468**	0,444**
Alertness and AUC	0,431**	-	-
Calmness and NWps	0,449**	0,405**	0,333*
Crying and NWps	0,328*	0,348*	0,437**
Physical Movement and NWps	0,560**	0,533**	0,609**
Physical Movement and AUC	0,424**	0,314*	-
Muscle Tone and NW	0,383*	0,404**	0,413**
Facial Tension and NW	0,418**	0,391*	-
Facial Tension and AUC	0,327*	-	-

Notes: * $p < 0.05$; ** $p < 0.01$

Additional analyses of agreement between Cb and skin conductance was made using Kendall's coefficient of concordance. The Kendall rank correlation coefficient was calculated to the "difference during-before pain event" values between Cb general score and factors´scores and SCA variables (NW and AUC). No Kendall's coefficient of concordance was found between general score of Cb and SCA (NW and AUC) at 15sec interval, to NW 30sec were found only marginal significant values , but to NWps 180sec interval, it was found high significant Kendall's tau-b value (.313, p=.006). Looking at the factors and the three time intervals of SCA variables, it was found to 15sec agreement between Facial Tension and NWps 15sec (Kendall's tau-b= -.303, p=.023). To NWps 180sec, again Facial Tension (Kendall's tau-b= .363, p=.001), and also Muscular Tonus **(**Kendall's tau-b= .270, p=.021), Physical Movement (Kendall's tau-b= .299, p=.006), and Alertness (Kendall's tau-b= .321, p=.002).

Discussion

In our study, almost every factor of Cb were statistically significant (p < 0,005) when correlated with the SCA, evaluating the NWps, in the periods of analysis of 15sec, 30sec and 180sec. Despite the statistical significance between the variables of the Cb, the overall score of the scale when compared with the SCA variables by Spearman's Bivariate correlation showed a weak correlation (r < 0,50). This result may suggest that the scale, although validated for the measurement of pain in newborns, behaves more for chronic pain, when the analysis time is longer than 2 minutes while SCA is more sensitive and specific for the measurement of acute pain in small instant of seconds (15sec) after the heel prick. Corroborating this idea, we found that there was a statistical correlation only when sub items of the scale were compared with the number of waves in180sec suggesting that the pain response is delayed even when taken into consideration the Cb. Only the variable of facial expression was not correlated with the NWps in 180sec. This can be due to the low carrying capacity of muscle seen in newborns or even due to misinterpretation of the observer. In fact, a study with 27 full-term healthy newborns, which compared in combination with behavioral and physiological measures of skin conductance, suggested that the AUC was the variable most sensitive and specific in measuring pain levels (Eriksson *et al.,* 2008). However, in this present study, correlation was observed during the 15sec with the factors analysis physical movement and facial expression with $p = 0.037$ $r = 0,327^{*}$ and $p = 0.006$ $r = 0,424^{**}$respectively. The lack of correlation with other variables of the Cb can be explained due to interference or artefact, making it necessary for automatic recognition of filtering.

The analyses of agreement between Cb and SCA by Kendall's coefficient of concordance pointed that its scores are more related to values of SCA more for late intervals (180sec), far from the time interval more related to the pain event (15sec). Facial Tension seems to be the gold standard of this scale as it kept in high levels all over the behavioural observation time. Otherwise, factors as Crying and Calmness can be considered poor indicators of pain. Other factors as Muscle Tone**,** Physical Movement and Alertness only agreed with time interval of 180sec. Nevertheless, all agreements were only to NWps and all were only in a fair level of agreement, which was expected as the SCA is a highly fast way to measurement compared to behavioral scales.

The Cb should be evaluated in structured its three dimensions or components that comprise (Ambuel *et al.*, 1992) physiological, phenomenological and behavioral. Analyzing under this theoretical approach, it is possible to assume that the SCMS® system, built to be sensitive not only to physiological dimension but also to the emotional one, and the facial tension factor of Cb are more related to the physiological level, while factors as alertness, physical movement and muscle tone are more related to the phenomenological dimension.

The phenomenological component of a behavioral scale, described as the personal account of pain, anxiety, among others, is the most difficult to assess in newborns since they are unable to speak. According to Ambuel *et al* (1992), anxiety can exist even in the absence of pain while the pain is related to an external noxious stimulus able to activate ascending cortical pathways for perception and interpretation of pain, and descending pathways to the development of a response (Anand *et al*., 2007). Associated with this mechanism, researchers assessed that these mechanisms are integrated with the sympathetic nervous system by changing the conductance of the skin due to the release of acetylcholine at postganglionic synapses of the muscarinic receptors of the sweat glands (Storm, 2008). According to the behavioral component, can be observed in this study that all the behavioral variables of the Cb when conducting an assessment using non-parametric pair before-during and during-after the procedure (heel prick) showed differences statistically significant but a weak correlation between SCA variables and the scale. Thus, it allows inferring that this variation in the score of each variable follows the variation of the scale of perception/response to pain by the newborn. Hence, the data also allow raising the hypothesis of responses like increase in physical movements, muscle tone and alertness is likely signals of anxiety than pain. To study this premise it could be suggested, in future studies, instead of considering the COMFORT´s entire interval of two minutes, to use varieties of observation behavior strategies as time sample, splitting the time window in smaller intervals searching for the decay of some responses and the raising of others. In that way it would be possible to define which responses are more related to the past painful event and which are related to fear of future pain.

Acknowledgments

This research was sponsored by grants from FAPDF, CNPq and FAHUB for the purchase of equipments and also received the support of the staff from Neonatal Intensive Care Unit, University of Brasilia Hospital, Brasília, Brazil. Special thanks to the mothers and babies. Thanks also to Marcos Vinícius Melo de Oliveira for the video analysis of the COMFORT scale.

References

Ambuel B., Hamlett K. W., Marx C. M. & Blumer J. L. (1992). Assessing distress in pediatric intensive care environments: the COMFORT scale. *J Pediatr Psychol, 17*, 95–109.

Aydede, M. (2010). "Pain", *The Stanford Encyclopedia of Philosophy (Spring 2010 Edition)*, Edward N. Zalta (Ed.) [http://plato.stanford.edu/archives/spr2010/entries/pain/; last accessed on 2012 jan 29].

de Oliveira M. V. M., de Jesus J. A. L. & Tristão R. M. (2012). Psychophysical parameters of a multidimensional pain scale in newborns. *Physiol. Meas., 33*, 39–49.

Eriksson M., Storm H., Fremming A. & Schollin J. (2008). Skin conductance compared to a combined behavioural and physiological pain measure in newborn infants. *Acta Pædiatrica, 97*(1), 27–30.

Gjerstad A. C., Storm H., Hagen R., Huiku M., Qvigstad E. & Raeder J. (2007). Comparison of skin conductance with entropy during intubation, tetanic stimulation and emergence from general anaesthesia. *Acta Anaesthesiol Scand, 51*(1), 8–15.

Gjerstad A. C., Wagner K., Henrichsen T. & Storm H. (2008). Skin conductance versus the modified COMFORT sedation score as a measure of discomfort in artificially ventilated children. *Pediatrics, 122*(4), 848-53.

Grunau R. V. & Craig K. D. (1987) Pain expression in neonates: facial action and cry. *Pain, 28*(3), 395-410.

Harrison D., Boyce S., Loughnan P., Dargaville P., Storm H. & Johnston L. (2006). Skin conductance as a measure of pain and stress in hospitalised infants. *Early Human Development, 82*(9), 603—608.

Hullet B., Chambers N., Preuss J., Zamudio I., Lange J., Pascoe E. & Ledowski T. (2009). Monitoring Electrical Skin Conductance: A Tool for the Assessment of Postoperative Pain in Children? *Anesthesiology, 111*(3), 513–7.

Hummel P., Puchalski M., Creech S. D. & Weiss M. G. (2008). Clinical reliability and validity of the N-PASS: neonatal pain, agitation and sedation scale with prolonged pain. *J. Perinatol., 28*(1), 55-60.

Hummel P., Lawlor-Klean P. & Weiss M. G. (2010). Validity and reliability of the N-PASS assessment tool with acute pain. *J. Perinatol., 30*(7), 474-8.

IASP Task Force on Taxonomy (1994). "Part III: Pain Terms, A Current List with Definitions and Notes on Usage" (pp 209-214) Classification of Chronic Pain, Second Edition, IASP Task Force on Taxonomy, edited by H. Merskey & N. Bogduk, IASP Press, Seattle.

Jesus, J. A. L.; Tristao, R. M.; Storm, H.; Rocha, A. & Campos Junior, D. (2011). Heart rate, oxygen saturation, and skin conductance: A comparison study of acute pain in Brazilian newborns. *Conference Proceedings IEEE Engineering in Medicine and Biology Society, 30*, 1875-1879.

Lawrence J., Alcock D., McGrath P., Kay J., MacMurray S. B. & Dulberg C. (1993). The development of a tool to assess neonatal pain. *Neonatal Netw., 12*(6), 59-66

Merskey H. & Bogduk N. (1994). Classification of Chronic Pain. Seattle: IASP Press: 210.

Padhye N. S., Williams A. L., Khattak A. Z. & Lasky R. E. (2009). Heart rate variability in response to pain stimulus in VLBW infants followed longitudinally during NICU stay. *Dev. Psychobiol*., *51*(8), 638-49

Pereira A. L. S. T., Guinsburg R., Almeida M. F. B., Monteiro A. C., Santos A. M. N. & Kopelman B. I. (1999). Validity of behavioral and physiologic parameters for acute pain assessment of term newborn infants. *São Paulo Med. J.*, *117*(2), 72-80

Ranger M., Johnston C. & Anand K. J. S. (2007). Current Controversies Regarding Pain Assessment in Neonates. *Semin Perinatol, 31*(5), 283-288.

Storm H. (2001). The development of a software program for analyzing skin conductance changes in preterm infants. *Clinical Neurophysiology, 112*(8), 1562-1568

Storm H. (2008). Changes in skin conductance as a tool to monitor nociceptive stimulation and pain. *Current Opinion in Anaesthesiology, 21*, 796–804.

van Dijk M., de Boer J. B., Koot H. M., Tibboel D., Passchier J. & Duivenvoorden H. J. (2000). The reliability and validity of the COMFORT scale as a postoperative pain instrument in 0 to 3-year-old infants. *Pain*, *84*(2-3), 367-377.

van Dijk M., Peters W. B., van Deventer P. & Dick Tibboel (2005). The COMFORT Behavior Scale: A tool for assessing pain and sedation in infants. *Am J Nurs, 105*(1), 33-6.

Stevens, Riddell, Oberlander & Gibbins (2007). Assessment of pain in neonates and infants. In KJS Anand, BJ Stevens & PJ McGrath (Eds.), Pain in Neonates and infants (third Edition) (pp. 67-90).

Storm H. & Fremming A. (2002). Food intake and oral sucrose in preterms prior to heel prick. *Acta Paediat., 91*, 555-60.

van Dijk, M., Peters, J. W., van Deventer, P., Tibboel, D. (2005). The COMFORT behavior scale: a tool for assessing pain and sedation in infants. *Am. J. Nurs., 105*, 105-133