NEONATAL PAIN BEHAVIOUR AND PERINATAL EVENTS: IMPLICATIONS FOR RESEARCH OBSERVATIONS

Ruth V.E. Grunau, Kenneth D. Craig and Jane E. Drummond

Pain in early infancy has only recently been recognized as an area requiring systematic study in nursing (Owens, 1984; Roberts, 1988). This has emerged in part because of recognition of the need for an empirical base for pediatric pain management (Russo & Varni, 1982), but also reflects changes in views regarding neonatal functional capacity in other modalities (Emde & Robinson, 1979; Stratton, 1982). In the past, there have been widespread erroneous beliefs held that neonates were relatively insensitive to pain, perhaps as part of a system of protection during the birth process (Bondy, 1980). Studies of healthy neonates during circumcision (Dixon, Snyder, Holve & Bromberger, 1984; Gunnar & Malone, 1985; Marshall, Stratton, Moore & Boxerman, 1980) and heel lance for blood collection (Grunau & Craig, 1987; McKeel & Sanders, 1984; Owens & Todt, 1984) have now demonstrated vigorous and dramatic behavioral responses to noxious stimulation which adults would interpret as pain in response to tissue damage (Craig & Grunau, in press).

The possibility that variations in pain behavior in the first few days of life may reflect perinatal variables, such as mode of delivery and maternal obstetric medication, was raised 30 years ago by Lipsett and Levy (1959), and again by Fisichelli, Karelitz, Fisichelli and Cooper (1974). However, to our knowledge, this issue has never been addressed empirically. Other concomitant factors, such as time from last feeding prior to the invasive procedure, and type of feeding (breast vs. bottle) at a time when breast milk supply may not yet be well established, may also affect pain behavior. Difficulties inherent in attempting to determine causal relations between obstetric drugs or other perinatal variables and neonatal behavior, in the light of confounding of maternal and obstetric factors, have recently been described (Kraemer, Korner, Anders, Jacklin & Dimiceli, 1985).

Ruth V.E. Grunau Ph.D. is a Psychologist with British Columbia Children's Hospital in Vancouver. Kenneth D. Craig Ph.D. is a Professor of clinical psychology at the University of British Columbia in Vancouver. Jane E. Drummond R.N., M.Sc. is Assistant Professor of Nursing at the University of Alberta in Edmonton.

The Canadian Journal of Nursing Research *Fall 1989, 21(3), 7-17*

The aim of the present study was to identify factors that may contribute to variability in the behaviour of newborns and that have remained unexplained in neonatal pain studies. There was no intention to evaluate perinatal events as reflecting either potentially adverse or beneficial practices in relation to obstetric pain management. Rather, the aim was to examine associations between obstetric and other concurrent events, in relation to pain behavior. This was done using fine grained analysis of facial activity, which has been found to be a sensitive indicator of induced laboratory pain and clinical pain in adult chronic pain patients (Craig & Patrick, 1984; Craig & Prkachin, 1983; Grunau & Craig, 1990; Hyde, 1986), and significantly related to cry latency during blood collection in neonates (Grunau & Craig, 1987). Neonates were videotaped while hospital laboratory technicians performed heel lances for routine blood sampling purposes. A coding system for facial activity was developed, based on the Facial Action Coding System approach to coding discrete facial movements (Ekman & Friesen, 1978). The system incorporated Oster's proposals for coding babies' faces (Oster, 1978). Grunau and Craig (1987, 1990) describe the coding system (see Table l). For the purpose of exploring perinatal variables, only the overall amount of facial activity was examined.

Method

Subjects

A continuous sample of 77 boys and 63 girls from the well-baby unit of a major metropolitan university affiliated maternity teaching hospital participated in the study. The mean age of the infants was 43.05 hrs (SD = 7.06 hrs). Criteria for inclusion were: birthweight above 2500 gm; gestation of 38 to 42 weeks; Apgar rating at five minutes of 8 to 10; circumcision had not taken place. Mean birthweight was 3446.4 gm. Mean maternal age was 29.4 years (range 17 to 42 years); 89 (63%) of the mothers were white, 38 (27%) Oriental, 8 (6%) East Indian and the remaining 4% comprised 4 Filipino and 1 Native North American Indian. Mode of birth was 72 (52%) spontaneous vaginal, 34 (24%) vaginal forceps, 21 (15%) planned Caesarean section and 13 (9%) Caesarean section following labour.

Apparatus

A color camera was used for video recording with 3/4" video tape. An AKG D109 Lavalier microphone was suspended approximately 18 cm from the infant's mouth. To cue the heel-lance event, an inaudible tone of 1000 Hz was recorded on the audio portion of the video system. The original 3/4" videotapes were copied onto 1/2" VHS tapes with a digital time display superimposed for coding purposes. A video cassette recorder with remote control and a playback color monitor were used during video coding.

Measures

Facial activity and sleep/waking state were assessed using the videotaped recordings of the infant. These measures have been found to be related to facial activity following heel lance (Grunau & Craig, 1987, 1990). The remaining perinatal variables were compiled from the hospital chart.

Sleep/wake state. The following observational rating system was used for sleep/waking state: (l) eyes closed, no facial movement (quiet/sleep); (2) eyes closed, facial movement (active/sleep); (3) eyes open, no facial movement (quiet/awake); (4) eyes open, facial movement (active/awake). State was recorded by the first author in the nursery, over a 60-second period. Infants who were crying at the time sleep/waking state was recorded were excluded from the study, as they were judged to be already in a maximal state of arousal.

Facial Movement. The coding system for neonatal facial movement (see Table 1) (Grunau & Craig, 1987) was used by a coder who had been trained in the adult FACS system (Ekman & Friesen, 1978). The coder was "blind" to the purpose of the study and the perinatal data. Coding was carried out using a slow motion and stop-frame video feedback system. Occurrences of each of the seven facial actions were scored for each of five consecutive three-second time segments following heel lance, then summed, providing a measure of total facial activity.

Obstetric, perinatal and concurrent variables. The following information was taken from the hospital chart: type of birth (spontaneous vaginal, vaginal forceps, planned caesarean section, caesarean section following labour), type of obstetric maternal medication, duration of labour, gestational age in weeks, birthweight, head circumference, Apgar at one minute and five minutes, type of feeding (breast or bottle), maternal age and parity. Time from last feeding to heel-lance also was recorded.

Obstetric analgesia/anesthesia was ranked on an ordinal scale (Lester, Als & Brazelton, 1982), with modifications to reflect drug combinations used in Grace Maternity Hospital, Vancouver, B.C.. Type of obstetric medication was defined as follows: 1 = none; 2 = inhalation (50% N^2O in oxygen); 3 = perineal infiltration of local anesthetic; 4 = combination of two and three; 5 = epidural; 6 = combination of 2 and 5 or 3 and 5; 7 = combination of 2, 3 and 5; 8 = narcotics; 9 = combination of 2 and 8 or 3 and 8 or 2, 3 and 8; 10 = combination of 5 and 8 or 3, 5 and 8; 11= general anesthesia. None of these mothers were given sedatives or tranquilizers. Number of different drugs administered was recorded for the subset of infants born by spontaneous vaginal delivery. This was an observational study, with no control over frequency, dosage and total amount of medication.

Table 1

Neonatal Facial Coding System

Action	Description
Brow Bulge	Bulging, creasing and vertical furrows above and between brows occurring as a result of the lowering and drawing together of the eyebrows.
Eye Squeeze	Identified by the squeezing or bulging of the eyelids. Bulging of the fatty pads about the infant's eyes is pronounced.
Naso-labial Furrow	Primarily manifested by the pulling upwards and deepening of the naso-labial furrow (a line or wrinkle which begins adjacent to the nostril wings and runs down and outwards beyond the lip corners).
Open Lips	Any separation of the lips is scored as open lips.
Stretch Mouth	Characterized by a tautness at the lip corners coupled with a pronounced downward pull on the jaw. Often stretch mouth is seen when an already wide open mouth is opened a fraction further by an extra pull at the jaw.
Taut Tongue	Characterized by a raised, cupped tongue with sharp tensed edges. The first occurrence of taut tongue is usually easy to see, often occurring with a wide open mouth. After this first occurrence, the mouth may close slightly. Taut tongue is still scorable on the basis of the still visible tongue edges.
Chin Quiver	An obvious high frequency up-down motion of the lower jaw.

Procedure

Informed consent was obtained from a parent, usually the mother. PKU testing was conducted in a quiet room near the nursery, between 7 a.m. and 9 a.m., on the second day post delivery. Video and sound recording were carried out prior to and during this heel/lance procedure. The camera provided a close-up view of the infant's face at all times. The baby remained partially swaddled in the bassinet. The lab technicians' standard protocol involved: checking the infant's identification band on either the wrist or ankle; picking up the foot and rubbing it with disinfectant; the heel-lance procedure in which a small disposable metal scalpel (4.9 mm long point microlance) was used for incision. The heel then was squeezed and blood samples were collected on four circled areas on an absorbent card.

Data analysis

It has been found that parents differentially judge neonatal pain sensation using impressions of the amount of facial movement (Craig, Grunau & Aquan-Assee, 1988), and it is probable that nurse practitioners would do the same. Therefore, instead of using total facial activity as a continuous measure, scores below the median were categorized as low facial movement and those at or above the median were categorized as high facial movement.

Results

Stepwise discriminant analysis of the obstetric/perinatal/ concomitant variables to low and high facial movement showed statistically significant ($p < .01$) relationships for obstetric medication, $F(1, 130) = 14.62$, $p < .001$ and mode of delivery, $F(1, 130) = 11.60$, $p < .001$, independent of sleep/waking state. High facial movement was associated with greater obstetric medication ($M = 5.44$, $SD = 3.02$), as compared with the low facial movement group ($M = 4.52$, $SD = 2.95$). Classification results are shown in Table 2.

Table 2

Classification Results of Low and High Facial Movement to Heel Lance

Actual Group Membership	Predicted Group Membership	
	Low Face Action	High Face Action
Low n = 52	39 (75%)	13 (25%)
High n = 88	25 (28%)	63 (72%)
	Overall 73%	

Detailed exploration of the relationships of specific types of medication and modes of birth to facial action was beyond the scope of this study because of the small samples at this level of analysis and lack of systematic control over confounding variables. Therefore means are presented (Tables 3 and 4) for interest, for examination of possible trends; no statistical analyses were carried out on these means. No medication, or epidural alone, appeared to be related to less facial action than either combinations of epidural with other drugs or general anesthetic. Spontaneous vaginal birth and planned caesareans showed slightly less facial action than the possibly more "stressful" forceps or unplanned caesarean section. However, medication and delivery mode were confounded as the more difficult deliveries also received higher levels on the medication scale. Type of obstetric medication was highly related to mode of delivery, $X^2(36) = 154.07$, $p < .0001$. All women who received general anesthesia had a caesarean delivery. Of the 20 women who received epidurals only, 10 were planned caesareans, whereas half the mid or high forceps deliveries had received nitrous oxide in oxygen by mask or a local in addition to epidural medication.

Table 3

Mean Facial Movement to Heel-Lance by Type of Obstetric Medication

Obstetric Medication	n	M	SD
None	17	23.47	3.14
50% Nx/0 by mask	7	24.43	5.83
Local	17	25.34	4.62
50% N^20 + Local	27	25.85	4.52
Epidural	20	22.95	5.67
Epidural + 50 % N^20 or Local	23	25.22	2.95
Epidural + 50% N^20 + Local	8	26.87	2.75
Narcotic + 50% N^20 or Local or both	3	25.67	4.73
Epidural + Narcotic	6	26.67	1.86
General	12	26.17	3.13
Total	140		

Table 4

Mean Facial Movement to Heel Lance by Delivery Mode

	Spontaneous Vaginal	Forceps	Planned Section	Emergency Section
M	24.93	25.82	24.09	25.00
SD	4.22	3.63	5.58	2.97
n	72	34	21	13

A second discriminant analysis was carried out using data provided by the 72 infants of spontaneous vaginal deliveries only, none of whom had exposure to narcotics or general anesthesia. This was done to clarify whether the significant relationship between facial action and obstetric medication might have been related to a wider range or duration of drugs administered for forceps and emergency caesarean deliveries, or to unknown interactions with delivery mode. The number of different obstetric drugs administered was added to the set of predictor variables. This measure was considered inappropriate for the total sample because of the lack of comparability between number of drugs administered for planned cesarian versus other deliveries, and, for analgesia versus general anaesthesia. Analysis of each predictor variable showed statistically-significant differences in obstetric medication, $F(1, 70) = 9.75$, $p < .003$, and number of different drugs administered, $F(1, 70) = 10.35$, $p < .002$, between low and high facial activity groups. Following a stepwise discriminant analysis, because of multicollinearity, only the number of different drugs administered remained statistically significant in identifying level of facial activity, $F(1, 66) = 18.02$, $p < .001$), with an overall correct hit rate of 74%. The more drugs administered, the greater the subsequent facial activity in response to a pain inducing event.

The relationships reported between perinatal variables and pain expression were based on non-random assignment of subjects to groups; as such, it appeared very important to consider concomitant variables that may be related to delivery mode and obstetric medication. In the total group, mode of delivery was significantly related to parity, $X^2 (9) = 34.27$, $p < .0001$. There were significantly more forceps deliveries and emergency caesarean deliveries for first time mothers than for women who had undergone childbirth previously. Conversely, of the 24 women having their third or fourth baby, 71% had spontaneous vaginal deliveries and none were emergency

caesarean. Within the subsample of vaginal deliveries, correlations among several perinatal variables were calculated (see Table 5). Type, duration and number of drug administrations during labour and delivery were significantly related to duration of labour and parity. The infant's head circumference was significantly correlated with obstetric medication variables as well.

Table 5

Correlations Between Obstetric Medication and Perinatal/Infant Variables of Vaginal Deliveries

	Duration of Labour	Birth Weight	Head Circum.	Length	Parity
Type of Maternal Medication	.51**	.07	.36**	-.02	-.55**
Duration of Drug Administration	.59**	.03	.21	-.02	-.57**
Number of Drugs Administered	.55**	.07	.27*	.00	-.57**
Parity	-.53**	.06	-.06*	.05	
Maternal Age	-.01	.04	.01	.14	.26*

* $p < .01$
** $p > .001$

Discussion

Obstetric medication and delivery mode were examined in this study to determine whether they influence neonatal pain behaviour, thereby adding to uncontrolled error variance in research investigations. Pain research in this age group has treated healthy neonates as if they were an homogeneous group. A major review article in this area does not mention sample selection (Owens, 1984). The present findings suggest pain behavior in neonates reflects differences in obstetric procedures. Thus, in the study of pain reaction in this age group, specifying birth circumstances appears important. This study was not designed to evaluate behavioral variation in relation to specific maternal medications or modes of delivery. There was a wide variety of drugs, dosages and combinations. This is a highly complex topic and these findings only scratch the surface.

The depressant effect of narcotics and barbituates, which may persist for as long as two to four days after birth has been documented (Albright, Ferguson, Joyce & Stevenson, 1986; Bonica, 1980; Committee on Drugs, 1978). Thus, the possibility that the medication effect found on total facial movement after pain may have represented only those infants whose mothers had received general anesthetics or narcotics was explored. It was evident, however, that obstetric medication was highly related to total facial movement, even when only spontaneous vaginal deliveries with no narcotics administered were analyzed.

The finding of more facial movement to pain on the part of infants who had experienced more "stressful" deliveries, often involving higher levels of maternal medication, suggested they may have been more irritable and perhaps less able to modulate responses to nociceptive stimulation. However, another possibility is that a self-selection process may occur. Perhaps the less reactive mothers tend to receive less medication and their children are in some way expressively less reactive newborns. This may be mediated by constitutional, temperamental factors or by maternal physiologic factors during labour and delivery. Another possibility is that endogenous endorphins may be produced by nonmedicated mothers; in medicated mothers, as their pain is controlled externally, endorphins, or other endogenous pain modulation systems, may remain inactive (C. Bradley, personal communication, April, 1985). Endorphins may be passed on to the infant, thereby modulating pain reception and expression. It is not known at what point in pre- or postnatal development the capacity to produce endorphins becomes present. Causal analyses of behavioral reactions to specific obstetric events would require very carefully controlled studies, with separate analyses for different delivery modes. Apart from length of labour and parity in evaluating medication effects, a multiplicity of other interacting factors are potentially important: control of dosage, number of drug administrations and drug combinations, as well as levels of maternal endorphins and ongoing maternal and infant physiological events.

In conclusion, perinatal events did affect pain expression in newborns. It was beyond the bounds of this study to delineate specifically the critical factors. However, the findings indicated sample selection for neonatal pain study should include attention to birth events in addition to infant measures that define the neonate as "healthy".

REFERENCES

Albright, G.A., Ferguson, J.E., Joyce, T.E. & Stevenson, D.K. (1986). *Anesthesia in obstetrics: Maternal, fetal, and neonatal aspects*. Woburn, MA: Butterworth.

Bondy, A. S. (1980). Infancy. In S. Gabel & M. T. Erickson (Eds.), *Child development and developmental disabilities*. Boston: Little, Brown and Co.

Bonica, J. J. (1980). *Obstetric analgesia and anesthesia*. Amsterdam: World Federation of Societies of Anesthesiologists.

Committee on Drugs, American Academy of Pediatrics. (1978). Effects of medication during labor and delivery on infant outcome. *Pediatrics, 62*, 402.

Craig, K. D. & Grunau, R. V. E. (in press). Neonatal pain perception and behavioural measurement. In K. J. S. Anand & P. J. McGrath (Eds.), *Neonatal pain and distress*. Amsterdam: Elsevier Science.

Craig, K. D., Grunau, R. V. E. & Aquan-Assee, J. (1988). Adult judgements of pain in neonates. *Canadian Journal of Behavioral Science, 20*, 442-451.

Craig, K. D. & Patrick, C. J. (1984). Facial expression during induced pain. *Journal of Personality and Social Psychology, 48*, 1080-1091.

Craig, K. D. & Prkachin, K. M. (1983). Nonverbal measures of pain. In R. Melzack (Ed.), *Pain measurement and assessment* (pp. 173-179). New York: Raven Press.

Dixon, S., Snyder, J., Holve, R. & Bromberger, P. (1984). Behavioral effects of circumcision with and without anesthesia. *Developmental and Behavioral Pediatrics, 5*(5), 246-250.

Ekman, P. & Friesen, W. V. (1978). *The Facial Action Coding System (FACS)*. Palo Alto, CA: Consulting Psychologists Press.

Emde, R. N. & Robinson, J. (1979). The first two months: Recent research in developmental psychobiology and the changing view of the newborn. In J. D. Noshpitz (Ed.), *Basic handbook of child psychiatry*, Vol. 1. New York: Basic Books.

Fisichelli, V. R., Karelitz, S., Fisichelli, R. M. & Cooper, J. (1974). The course of induced crying activity in the first year of life. *Paediatric Research, 8*, 921-28.

Grunau, R. V. E. & Craig, K. D. (1990). Facial activity as a measure of neonatal pain perception. In C. D. Tyler & E. J. Krane (Eds.), *Advances in pain research and therapy. Proceedings of the First International Symposium on Pediatric Pain*. New York: Raven Press.

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

Gunnar, M. R. & Malone, S. (1985). Coping with aversive stimulation in the neonatal period: Quiet sleep and plasma cortisol levels during recovery from circumcision. *Child Development, 56*, 824-834.

Hyde, S. (1986). *Facial expressive behavior associated with acute pain in a chronic low back pain population*. Unpublished doctoral dissertation, University of British Columbia, Vancouver, Canada.

Kraemer, H. C., Korner, A., Anders, T., Jacklin, C. N. & Dimiceli, S. (1985). Obstetric drugs and infant behavior: A reevaluation. *Journal of Pediatric Psychology, 10*, 345-353.

Lester, B. M., Als, H. & Brazelton, T. B. (1982). Regional obstetric anesthesia and newborn behavior: A reanalysis toward synergistic effects. *Child Development, 53*, 687-692.

Lipsitt, L. P. & Levy, N. (1959). Electrotactual threshold in the neonate. *Child Development, 37*, 1-16.

Marshall, R. E., Stratton, W. C., Moore, J. & Boxerman, S. B. (1980). Circumcision: Effects upon newborn behavior. *Infant Behavior and Development, 3*, 1-14.

McKeel, N. L. & Sanders, S. H. (1984, November). *An innovative measurement paradigm for new-born infant pain responses*. Paper presented at the Annual Meeting of the Association for Advancement of Behavior Therapy. Philadelphia.

Oster, H. (1978). Facial expression and affect development. In M. Lewis & L. A. Rosenblum (Eds.), *The development of affect*. New York: Plenum Press.

Owens, M. E. (1984). Pain in infancy: Conceptual and methodological issues. *Pain, 20*, 213-230.

Owens, M. E. & Todt, E. H. (1984). Pain in infancy: Neonatal reaction to a heel-lance. *Pain, 20,* 77-86.
Roberts, P. M. (1988, June). Pain in the neonate. *Canadian Nurse,* 17-19.
Russo, D. C. & Varni, J. W. (1982). *Behavioral Pediatrics*. New York: Plenum.
Stratton, P. (1982). *Psychobiology of the human newborn*. New York: Wiley & Sons.

This research was supported by research grants to the second author from the Social Sciences and Humanities Research Council and the Natural Sciences and Engineering Research Council of Canada.

We wish to thank Tom Armstrong and the staff of Grace Hospital, Vancouver, B.C. for their assistance. Our appreciation is expressed to Dr. G.H. McMorland, Head of Anesthesiology at Grace Hospital for adapting the obstetric medication scale, and to Dr. McMorland and Dr. Christine Bradley, Director of Research, Nursing Division, Vancouver General Hospital, for their helpful comments on an earlier draft of this paper.

RÉSUMÉ

Les circonstances périnatales et le comportement du nouveau-né face à la douleur: considérations pour la recherche

On a établi un lien significatif entre la médication obstétricale administrée à la mère et le comportement du nouveau-né face à la douleur le matin du deuxième jour suivant la naissance. On a examiné l'activité faciale après incision du talon à la lancette chez 140 nouveaux-nés par rapport aux circonstances de l'accouchement. On a établi une corrélation entre une activité faciale plus vigoureuse et une posologie plus élevée de médication obstétricale, même s'il s'agissait en général d'accouchements plus difficiles. Ces observations portent à croire qu'il faut faire preuve de plus de circonspection lors du choix des circonstances périnatales à retenir pour constituer les échantillons de nourrissons destinés aux études sur la douleur néonatale.

THE UNIVERSITY OF MANITOBA
Probationary/Tenure Track Faculty Positions

Applications are invited for three probationary (tenure track) appointments at the school of Nursing, University of Manitoba.

Activities: (1) teaching nursing courses in the Undergraduate programs in the areas of Long-term/Chronic Care; (2) and/or teaching courses in the Master of Nursing program in the areas of Curriculum Development and Design, Nursing Administration or Physiological Nursing; (3) participation in the thesis/practicum supervision of graduate students in the Master's of Nursing program in area of expertise; (4) maintaining an on-going program of research and scholarship; (5) participation in school, university and professional activities.

Qualifications: Preference will be given to candidates with: (1) an earned doctoral degree or substantive progress towards a doctoral degree in nursing or in a related discipline. Outstanding candidates with master's degree in nursing or closely related disciplines may be considered; (2) evidence of advanced research training and the development of an on-going research and publication program; (3) experience in teaching nursing at a university; (4) where relevant, clinical experience; (5) demonstrated ability in establishing collegial relationships.

Both men and women are encouraged to apply. In accordance with Canada Immigration requirements, priority will be given to Canadian citizens or permanent residents. Rank and salary will be commensurate with qualifications and experience. Registration with the Manitoba Association of Registered Nurses is required.

Applications should be directed to:

Dr. J. Larsen, Director

School of Nursing, University of Manitoba, Winnipeg, Manitoba, R3T 2N2.

Applications will be accepted until the position is filled.