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Pain assessment in neonates

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Pain assessment is important in neonates. There are a variety of neonatal pain instruments currently being used. The components of the pain scales are identified and the validity and reliability of the different scales are described. Their applicability to pain assessment in clinical practice is discussed.

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Introduction

The studies of Anand and colleagues[1-3] on pain and its effects in preterm neonates published in the late 1980s were instrumental in changing the attitude to pain in premature neonates. It is now believed they not only have the neurological capacity to experience pain, but that they are more vulnerable to pain than are older infants and adults. A survey in 1988 among English anaesthetists showed that while 80% of the respondents considered neonates capable of experiencing pain, only 52% gave them opioids after surgery[4]. The respondents pointed out that objective methods of determining pain intensity in neonates were lacking. Since then, efforts have been made to improve pain management in this vulnerable age group. A variety of valid and reliable pain assessment instruments were developed to this end.

These pain assessment instruments contain several general indicators of pain, which will be described and discussed below. All the neonatal pain assessment tools are schematically reviewed and their usefulness for daily clinical practice is described.

Indicators of pain in neonates

Facial expression

Facial expression is generally considered the most sensitive indicator of pain in neonates[5-7]. Total facial activity and a cluster of specific facial features (brow bulge, eye squeeze, nasolabial furrow and open mouth) have been shown to be significantly associated with acute and postoperative pain[7,8]. As instruments based on facial expression have primarily been tested during or directly after short painful procedures their usefulness during more chronic pain states is unsure. Another drawback is the phenomenon that neonates also show considerable variability in facial expression during non-painful episodes[9]. Furthermore, assessment of facial expression may in practice be hampered by limited view of the neonate's face, due to tapes or eye patches during phototherapy. An example of a unidimensional instrument focusing on facial expression is the Neonatal Facial Coding System (NFCS), which assesses ten discrete facial actions, either from videotaped material[7] or from bedside observation[10]. Reduction to five facial actions leaves the NFCS still valid for postoperative pain assessment in neonates[11].

Table 1 Components of 17 neonatal pain instruments

Pain scale	Facial expression	Body movement	Cry	Physiological state/sleep	Behaviour	Posture/ tone	Skin colour	Consolability
Procedural								
NIPS	+	+	+	+	+	-	-	-
BPS	+	+	-	-	-	+	-	+
DSVNI	+	+	-	+	-	-	+	-
DAN	+	+	+	-	-	-	-	-
SUN	+	+	+	+	+	+	-	-
BPNS	+	-	+	+	+	+	+	+
PAIN	+	-	+	+	-	+	-	-
COVERS	+	+	+	+	-	-	+	-
NNICUPAT[1]	+	+	-	+	-	-	+	-
Post-operative								
PIPP*[2]	+	-	-	+	+	-	-	-
COMFORT-B**	+	+	+	-	+	+	+	-
PAT[1]	+	-	+	+	+	+	+	-
CRIES	+	-	+	+	+	-	-	-
CHIPPS	+	+	+	-	-	+	-	-
LIDS[3]	+	+	+	-	+	+	-	-
Ongoing								
N-PASS†	+	-	+	+	+	+	-	-
EDIN[4]	+	+	-	-	+	-	-	+
Frequency								
n	17	12	12	11	10	9	4	3
%	100	71	71	65	59	53	23	18

*Procedural and postoperative pain
**The original COMFORT scale included two physiological items (heart rate and mean arterial pressure) and is validated for procedural and sedation purposes. The COMFORT-B is validated for post-operative pain and sedation purposes.
† Ongoing pain and sedation
[1]Additional component is nurse perception of pain
[2]Additional component is gestational age
[3]Additional component is spontaneous excitability
[4]Additional component is contact with nurses

Total facial activity in most instruments is described in terms of 'relaxed' (score = 0) versus 'grimace' (score 1 or 2). Despite the general recognition of the sensitivity of facial expression for neonatal pain, only one multidimensional instrument, the Premature Infant Pain Profile (PIPP)[12-14], includes specific facial aspects: brow bulge, eye squeeze and nasolabial furrow, giving much weight to facial expression.

Body movement and (muscle) tone
Body movement may focus on activity of arms and legs, or more subtly, on the clenching of fists or toes when pain is felt. Pain assessment based on body movement is bound to present a misleading picture in the immobile painful infant. In neonatal pain instruments this item is represented by arm or leg movements, or extension of extremities.

Posture is assessed by observation and tone by touching the neonate's arm or leg. Tone and posture are thought to be more tense when pain is present. Muscle tone is either described by observation of clenched fists and toes or by feeling an arm or leg after the observation period to determine muscle tension. The latter may be undesirable in preterm neonates because it may be disturbing when they are asleep.

Crying
Cry features have been extensively studied using spectographic devices. This showed that short latency to onset of cry, longer duration of the first cry cycle, higher fundamental frequency and greater intensity in the upper ranges may be pain-specific cry features[8]. However, a study among *preterm neonates* suggested that cry (duration) is not an indicator of pain in this age group, because they *often do not cry in response to pain*[15]. Pain instruments (see Table 1) assess crying by either scoring intensity (whimpering, moaning vs. crying) or by scoring frequency (intermittent vs. long lasting). Some pain instruments, such as the Neonatal Infant Pain Scale (NIPS)[16] and Neonatal Pain, Agitation and Sedation Scale (N-PASS)[17] take crying in intubated infants into account, by scoring a crying face without vocalisation.

Behavioural state/sleep pattern
Although behavioural state is a modifying factor rather than an indicator of pain, it is included in most pain instruments. Behavioural state in neonates varies from quiet sleep to awake state with crying at the most extreme. The pain instruments offer different interpretations, however. The PIPP includes behavioural state because sleeping infants exhibit fewer sustainable responses[18,19].

Sleeping infants, therefore, score higher on this item than those awake, which corrects for the less vigorous responses to acute pain when asleep. All other pain instruments do the opposite, and assign higher scores for those who are more awake or who are unable to sleep. The underlying idea is that infants in pain are thought to have more difficulty falling asleep. A pitfall with this item in particular is the influence of environment on the ability to sleep. In a neonatal intensive care unit (NICU) environmental noise may distract a baby to the point that they are unable to fall asleep.

Consolability

Consolability, which assesses if an infant is consolable and how long it takes to calm the infant, is included in three of the neonatal pain instruments, the Behavioral Pain Score (BPS), the Bernese Pain Scale for Neonates (BPNS) and the Échelle Douleur Inconfort Nouveau-Né (EDIN) listed in Table 1[20-22]. Consolability seems to be a subjective and vague concept as there is no standard procedure on how to console a neonate. The BPS developed in 1994, has an item 'response to handling, consolability' which has the disadvantage that it actually incorporates two aspects. The EDIN[21] and BPNS[22,23], have incorporated consolability perhaps inspired by the increased use of the Newborn Individualised Developmental Care and Assessment Program (NIDCAP) treatment on NICUs For the EDIN, the item consolability ranges from 0 'quiet, total relaxation' to 3 'disconsolate, sucks desperately'. This leaves much to the interpretation of the observer. What has been done to console the infant? Although this item may be useful, more research is required to improve the wording of this aspect of pain assessment.

Skin colour

Four instruments from Table 1, respectively Pain Assessment Tool (PAT), Distress for Ventilated Newborn Infants (DSVNI), BPNS and Nepean Neonatal Intensive Care Unit Pain Assessment Tool (NNICUPAT) use skin colour as indication for pain. (One might argue whether skin colour is a physiological or behavioural indicator). High scores are given when infants are pale, mottled, bluish, grey, flushed or dusky. Does change in skin colour reflect pain or rather an illness-related symptom (e.g. congenital heart disease, sepsis) and if so, should it be judged as a mediating factor because the severely ill infants are less capable of expressing pain? The scientific papers describing the four instruments using skin colour do not give the answers to these questions.

Physiological indicators

Heart rate, blood pressure, oxygen saturation and breathing (frequency or irregularity) are the most frequently used physiological indicators of pain[24]. Heart rate and blood pressure will rise, oxygen saturation will decrease and breathing will become shallow or irregular. Other indicators primarily used in research are intracranial pressure[25], skin colour, palmar sweating and heart rate variability[26]. A drawback of these indicators is that deviations may also be caused by the underlying illness. This makes them less specific for pain[24,27,28]. Furthermore, daily medical interventions aim at keeping heart rate, blood pressure and oxygen saturation at acceptable levels without treating pain. Finally, several publications have confirmed that physiological indicators are not specific for pain in the postoperative setting[28-30].

However, 10 instruments include physiological indicators such as heart rate, blood pressure, oxygen saturation and breathing (frequency or irregularity). Decreases in oxygen saturation compared to baseline are used in the PIPP[12], or requirement for oxygen to maintain saturation > 95% in the CRIES (acronym for Crying, Requires O_2 for sat>95%, Increased vital signs, Expression and Sleepless) and the Pain Assessment in Neonates Scale (PAIN) as an indicator for pain[12,17,31-34].

The original COMFORT scale[35,36] included two physiological items as well. Studies in postoperative neonates and in non-surgical infants suggested that they could be deleted without loss of information[29,37,38]. The adapted version of the COMFORT ($COMFORT_{neo}$) scale for preterm neonates is currently being validated by our research group[37].

Heart rate is represented in pain instruments by either an increase in beats per minute (bpm) or by percentage of increase. The rationale for using an increase of 10 or 15% and not less to score higher on an item is lacking. Considering the high baseline heart rate of neonates it is possible that these percentages are too high. Increases in heart rate due to acute pain may be short lasting and therefore often remain unnoticed. Changes in vital signs are less useful for chronic pain. During surgery, physiological indicators are useful markers for increases in analgesia because the circumstances are controlled and standardised in contrast with the NICU situation.

During administration of high doses of neuromuscular blocking agents, heart rate and blood pressure are probably the only indicators to determine the need for analgesia and sedatives.

In our experience, these are only useful when the course of these parameters is accurately followed and compared over time.

Finally, although we lack evidence, it is our impression that there is a tendency in the NICU environment to trust numbers over behavioural observations. This may contribute to the ongoing use of physiological parameters in pain assessment.

Preterm neonates

Higher survival rates in premature infants have generated greater interest in pain assessment in prematurely born neonates over the past ten years. It has been suggested that their still immature central nervous system renders them less sensitive to pain compared to full term born infants[5,39-41]. This is a misconception, however, probably resulting from the fact that pain responses in preterm neonates are generally considered to be less than those exhibited in full term neonates. They show less facial expression, fewer body movements and do not always cry during painful procedures[5,40]. Increasingly more behavioural responses have been demonstrated to an acute painful stimulus in the same infants across 8 weeks of development[39].

Severity of illness

The severity of illness may cause less explicit pain reactions. Restricted, slow movements and a blank face may be the reflection of severe pain such as in necrotising enterocolitis[21]. Infants lacking energy due to the severity of their illness consequently are less capable of signalling pain e.g. by crying[42]. Clinical practice confirms this notion and health professionals should be aware of this pitfall in pain behaviour.

Pain instruments

A variety of pain assessment instruments have been developed, based either on behavioural indicators of pain alone or on a combination of behavioural and physiological indicators. While the combined instruments are multidimensional by nature, the others tend to focus on one behavioural aspect, for instance facial expression as in the NFCS[18]. Most instruments have been reviewed extensively by other authors[43-44]. Table 1 lists different neonatal pain assessment instruments[45-49]. There is considerable overlap in the components used to assess pain with facial expression in all the scales. Body movements, cry, behavioural state/sleep, posture/tone and physiological items are used in the majority of pain instruments.

Table 2 gives an overview of the psychometric properties tested for the individual instruments. Inter-rater reliability was estimated in eleven instruments. Unfortunately, in four studies Pearson's correlation coefficient was used to determine agreement between raters (NIPS, NNICUPAT, Children and Infants Postoperative Pain Scale, Liverpool Infant Distress Scale). This coefficient may overestimate agreement. The intraclass correlation coefficient (ICC) or Kappa statistic are more appropriate measures[50]. Internal consistency was addressed in eight studies. Validity testing was performed in several ways; firstly, by comparing the instrument with a comparable instrument or global pain score (high correlation coefficients are not surprising because of the similarity of instruments); secondly, by comparing pain scores in a painful and non-painful situation; thirdly, sensitivity to change (responsiveness) is tested by comparing before and after administration of analgesia.

The observation period is clearly defined in only seven instruments. In our opinion, this is relevant because this period should be identical between observers. The EDIN scale was specifically designed for prolonged pain[21] and scoring is therefore based on the previous hour(s)[51].

Table 2 Testing of neonatal pain instruments

	Validity						
Pain scale	**Inter-rater reliability**	**Internal consistency**	**Concurrent validity**	**Known group comparison**	**Responsiveness**	**Sensitivity/ Specificity**	**Used for trials**
CHIPPS	+	+	+	+	+	+	+
COMFORT	+	+	+	+	+	+	+
NIPS	+	+	+	-	-	-	+
CRIES	+	-	+	-	+	-	+
PIPP	+	+	+	+	-	-	+
DAN	+	+	-	+	-	-	+
EDIN	+	+	-	-	+	-	+
N-PASS	+	+	+	+	-	-	-
LIDS	+	+	-	+	+	-	-
BPNS	+	+	+	+	-	-	-
NNICUPAT	+	-	+	-	-	-	-
PAIN	-	-	+	+	-	-	-
COVERS	-	-	+	+	-	-	-
SUN	-	-	+	+	-	-	-
BPS	-	-	-	+	-	-	-
PAT	-	-	-	-	-	-	-
DSVNI	-	-	-	-	-	-	-

Cut-off scores are a complex topic which explains why only six studies address this topic. A cut-off score for all patients may be disadvantageous because individual differences are not taken into account. An advantage of cut-off scores on the other hand is the fact that pain assessment is coupled to pain treatment.

Choice of pain scale
Table 2 gives details of the tested psychometric properties of the instruments from Table 1. For reliability we determined if inter-rater reliability and internal consistency of the instrument were tested. Validity testing was differentiated in concurrent validity (or more appropriately congruent validity where the instruments' correlation with another validated instrument is assessed), known group comparison (part of construct validity) and responsiveness (or 'sensitivity to change'). The naming of these validation tests is currently under debate, as well as the matter as to whether responsiveness is part of validation or not. For now we classify it as part of validation. Finally sensitivity and specificity of the different neonatal pain instruments is considered.

Table 2 gives details as to which instruments have been used in research after the first validation study. This may be helpful because peer-reviewed journals may reject reports of otherwise well-conducted trials if the instruments used have not been fully validated. The NIPS, PIPP, CRIES and the NFCS were selected by an international consensus meeting group[52]. The first two have been validated for acute procedural pain; the CRIES primarily for postoperative pain. The NFCS is primarily used in studies which use video material to assess the NFCS during painful procedures. Other sufficiently validated instruments may be considered as well.

Pain assessment in clinical practice

Despite the increasing number of pain assessment instruments, useful guidelines for daily practice on the NICU are missing. Guidelines for pain treatment should encompass both pain assessment and agreed interventions if pain is detected. As a golden standard for pain assessment is not available, these guidelines need to be derived from data from randomised controlled trials using pain assessment scales in a clinical setting.

The majority of instruments are primarily used for research purposes or validated for acute painful procedures. Expressing pain during a heel prick is an example of a normal response to a noxious event. Not expressing pain in such a situation may be of more concern. Limited expression of pain may occur in severely ill or very painful infants.

In daily practice we need to have a broader feel of comfort during day and night. Table 3 gives a proposed guideline for pain assessment in the NICU. In addition, pharmacological and non pharmacological interventions should be incorporated into protocols for different patient groups and painful situations.

The Newborn Individualised Developmental Care and Assessment Program (NIDCAP), developed in 1984, introduced a new way of treating and observing premature and very ill neonates. It includes adaptation of the environment to the specific needs of premature neonates. Decreasing noise by lowering alarm signals and decreasing light by covering incubators are examples of this. Periods of rest are provided by clustering of care, comfort is established by nesting and the use of pacifiers. Furthermore, daily care and painful procedures are performed by two nurses to limit stress and console the child during handling. These new interventions will have their impact on pain and sedation treatment as well. Therefore, more and more, focus will be on NIDCAP in relation to pain and (di)stress. Some researchers explored the usefulness of NIDCAP assessment for pain assessment. Grunau and colleagues investigated movements that reflect either stress or stability

Table 3 Proposed guidelines for pain assessment on the NICU*

Situation	Scoring
First day of admission	On admission or during first shift
Postoperative situation	On return from theatre. At least every 6 hours for first 24 hours
During analgesic treatment (e.g. IV morphine)	At least once every shift
During weaning of opioids (when opioids are given > 5 days)	30 minutes after every decrease and 30 minutes after discontinuation
Patients with significant pain	Before and after pain-relieving intervention
Patients with (suspected) necrotising enterocolitis, fractures or first 24 hours after vacuum extraction	At least once every shift

* These guidelines are rather restricted because motivation among nurses for scoring decreases when scoring is considered redundant.

Note: During acute painful procedures (heelprick, venepunctures, insertion of lines) the focus should be less on assessment and more on optimal treatment, for instance by using sucrose, containment, etc.

behaviours as indicated by the NIDCAP[53-55]. While twitches and startles were found not to be stress cues, finger splay and extension of extremities seemed useful as pain cues in preterm neonates in response to acute painful procedures, such as blood collection[53-56]. Future research needs to tell how NIDCAP, pain assessment and treatment are best combined. This will help to improve daily neonatal pain management.

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