

Measurement of Pain in Children

State-of-the-art Considerations

THE subject of pain in children and infants has received considerable attention during the past decade. Pain in neonates and children has historically been underreported, undertreated, and frequently misunderstood. Research comparing analgesic usage between adults and children began to emerge in the 1970s and consistently revealed that children received fewer, less frequent, and smaller doses of potent analgesics.¹⁻³ Recent investigations show limited improvement in prevailing practices in pain management in children⁴ despite efforts to change the purview and practice of clinicians. Wide variations still exist in practice philosophies in different pediatric centers.⁵ Although multiple methods have been described to measure and assess pain in children, most are not well-validated and not applicable to all age groups, and none have been universally accepted. Young children and children with cognitive disabilities are especially difficult to evaluate for pain because of their limited understanding and communication skills. Despite these difficulties, measurement of pain in children is of major importance for substantiating a therapeutic decision and evaluating the effectiveness of a particular intervention.

In this issue, Breau *et al.*⁶ report about the development and validation of the Non-communicating Children's Pain Checklist-Postoperative Version (NCCPC-PV). This publication is of particular importance because anesthesiologists have had significant difficulties in assessing postoperative pain in children with major cognitive disabilities. The perception of pain includes a sensory component, involving neural pathway activation in response to noxious stimuli, and an affective response, which involves behavioral and cognitive aspects. The International Association for the Study of Pain states that, "Pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage."⁷ Pain is what the subject says hurts.⁸ But how is pain described and mea-

sured in the preverbal or noncommunicating disabled child?

Pain is clearly subjective and no longer considered an experience in which pain intensity is *only* proportional to the objective degree of injury. It is certain that the pain experience cannot be separated into its physical and emotional components. The complex response to a noxious stimulus results in behavior that is unique and dependent on multiple factors, including one's experiences and perceptions. Pain experience in children is further complicated by the dynamic evolution of conscious awareness and psychologic and physiologic development. Therefore, pain assessment in children is dependent in large part on their level of understanding as well as their ability to convey to others the magnitude of their experience. Obviously, this ability to convey the existence of pain may be significantly limited in the disabled child.

In general, pain assessment instruments in children can be categorized as observational, self-report, and physiologic instruments. Because of the subjective nature of pain, *self-report methods* are considered the best measure of pain in children who are at least 5 or 6 yr old. These methods are less reliable in younger children and children with cognitive disabilities because they rely heavily on visual analogs, sensory associations, and verbal responses. For example, Hester's Poker Chip Tool was validated for children as young as 4 yr of age. However, both sensory and motor responses are required in selecting the "pieces of hurt."⁹ Therefore, the application of self-report scales is limited to children who can understand the objectives and descriptors of these techniques. Several *physiologic parameters* have been used to assess pain in children. These include changes in heart rate or in beat-to-beat heart rate variability, blood pressure, serum cortisol concentrations, transcutaneous oxygen tension, and palmar sweating.^{10,11} However, physiologic parameters can be influenced by a variety of processes, such as hypoxemia, hypovolemia, and fever, that are unrelated to pain *per se*. Because of the properties of self-report and physiologic measures, preverbal and cognitively disabled children benefit the most from observational measures. The most valuable *observational descriptors* are behaviors such as crying, facial expression, touch behavior, leg position, and general body movements. However, it should be noted that observational measures may be subject to limitations, such as difficulty to separate behavior associated with pain from that caused by fear and anxiety and underestimation of acute postoperative pain.¹²

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The observational pain assessment instrument described in the article by Breau *et al.*⁶ has to be evaluated in the more general context of a behavioral instrument used in clinical medicine. The development of such instruments in general, as well as those used particularly to assess pain in children, begins with the identification of all descriptors relating to the phenomenon measured. The original publication that described the development of the NCCPC-PV provides extensive content coverage and descriptors of areas related to pain in nonverbal, cognitively impaired children.¹³

The next step involves selecting an appropriate scale of measurement. S. S. Stevens¹⁴⁻¹⁶ made in the 1950s a lasting contribution to the classification of scales of measurement. Stevens¹⁴⁻¹⁶ was the first to conceive the idea of a measurement system that he designated as the familiar nominal, ordinal, equal interval, and equal ratio scales of measurement. The impact of Stevens' work has been great enough that the very words that he suggested, nominal, ordinal, equal interval, and equal ratio, find themselves expressed in every major work on research design.

Stevens¹⁴⁻¹⁶ also suggested an association between the scale type used and the level of reliability and validity of the phenomenon being measured. He indicated that each successive scale (nominal, ordinal, equal interval, and equal ratio) progresses in complexity, by incorporating the defining feature of each preceding scale and adding its own unique feature. The sequence is as follows: The simplest type of scale, a *nominal* scale, contains two or more unordered categories of the entity measured (*i.e.*, presence or absence of pain). At the next level of scale complexity, there are two or more categories of classification, as in nominal scales, but the defining feature that is added is that the categories are now ordered to form an *ordinal* scale (*i.e.*, slight pain, mild pain, moderate pain, severe pain). The third level of scale complexity would be the *equal interval* scale. This scale has three or more categories of classification (the nominal feature), and they are ordered (the ordinal feature), but the defining feature is that one can also identify points on the scale that are equal in interval size. For example, on a 10-point pain scale, a pain experienced as a 7 is to be interpreted as being exactly 3 points less than one of 10. However, the scale does not allow one to conclude that a pain score of 6 refers to twice as much pain as one of 3. The most complex scale, in Stevens' conceptualization, is the *equal ratio* scale of measurement. Such a scale has nominal, ordinal and equal interval features but now incorporates the additional feature of equal ratio categories of classification. For example, on a 10-point pain scale, a score of 2 represents twice as much pain as a score of 1, and a pain score of 9 indicates three times as much pain as a score of 3. The NCCPC-PV developed by Breau *et al.*⁶ classifies pain intensity as one of the following: "not at all," "just a little," "fairly often," and "very often." Therefore, at first look, the NCCPC-PV

can be classified as a dichotomous ordinal scale with an absence category followed by two or more categories of degree of presence of pain.¹⁷ However, it should be noted that the absence category is used so infrequently that the NCCPC-PV can for all purposes be treated as a continuous ordinal scale with no category of absence.

Interestingly, despite the existence of multiple interval and ratio scales in clinical medicine, most medical decisions are categorical in nature. For example, total cholesterol is measured on an equal ratio scale (*e.g.*, 300 mg/dl is twice as high as 150 mg/dl). However, this has little meaning medically. That is, a level of 300 mg/dl requires treatment, whereas a level of 150 mg/dl does not require treatment. It is also important to indicate that the same clinical phenomenon can be measured on different types of scales of measurement, depending on the research question. For example, if one needs to correlate cholesterol level with age at first myocardial infarction, one would measure cholesterol on an equal ratio scale. In this case, one would lose information and artificially lower the correlation by measuring cholesterol on an ordinal scale, such as 1 = ideal, 2 = borderline, and 3 = high.

S. S. Stevens also believed that in terms of the scientific quality of the information produced, equal ratio scales were superior to all others, equal interval scales were superior to both ordinal and nominal scales of measurement, and ordinal scales were superior only to nominal scales. The direct implication here is that the degree of reliability and validity of a phenomenon increases as a function of the complexity of the scale type. The issue of reliability and validity as a function the complexity of the scale type is currently a source of some debate. Although some scientists agree with the theory developed by Stevens,¹⁸ others strongly disagree. There is considerable research evidence that supports the contrary view to Stevens. For example, a study undertaken by one of the authors and his British colleagues showed that whether psychiatric diagnoses were made on nominal ordinal or equal ratio scales, the levels of interexaminer reliability were essentially interchangeable.¹⁹ Similarly, computer simulation research indicates that equal ratio scales are no more reliable than seven-category ordinal scales.²⁰ Therefore, we submit that the decision regarding the type of scale used has to be based solely on the nature of the clinical phenomena assessed.

Deciding on an optimal number of categories for a continuous ordinal scale, such as the NCCPC-PV, is a

Table 1. Clinical Significance of Sensitivity and Specificity Indices of Scales of Measurement

| Size of Reliability Coefficient | Level of Observed Agreement | Level of Clinical or Practical Significance |
|---------------------------------|-----------------------------|---|
| < 0.40 | < 70% | Poor |
| 0.40-0.59 | 70-79% | Fair |
| 0.60-0.74 | 80-89% | Good |
| 0.75-1.00 | 90-100% | Excellent |

complex issue that can be dated back to the early work of Symonds,²¹ almost eight decades ago. Most recently, an extensive computer simulation investigation, and an experimental investigation by Preston and Colman,^{20,22} indicate that scale reliability tends to increase as the number of categories increases. However, when the number of categories goes beyond seven, there tends to be no material increase in reliability.^{20,22} The NCCPC-PV can be classified as a four-category ordinal scale. Given the authors' statement that the absence category is virtually never applicable (at least in their pediatric sample), the NCCPC-PV can be reclassified as a three-category ordinal clinical rating scale. Therefore, a question of whether reliability would increase if the number of the NCCPC-PV categories were to be increased to seven can be raised. This is an intriguing question for Breau *et al.*⁶ as well as for the area of pain assessment in children.

Thus far, the discussion has been focused on issues related to the development of a clinical instrument. The last important issue relates to the reliability and validity of the clinical instrument that one develops. Because the appropriate model of the intraclass correlation coefficient (Ri) of chance-corrected agreement can be used with both ordinal and interval data,²³ the choice of Breau *et al.*⁶ of this statistic, as recommended in Shrout and Fleiss,²⁴ is appropriate. Also, the authors' calculation of sensitivity and specificity indices for the NCCPC-PV is entirely appropriate. Cicchetti²⁵ has recently published a set of criteria that can be applied to assess the clinical significance of sensitivity and specificity indices of scales of measurement (table 1). These guidelines apply whether the scale consists of nominal, ordinal, or mixed scales, such as the NCCPC-PV. Applying these criteria to the current article, a score of 11 on the NCCPC-PV showed very good sensitivity (88%) and good specificity (81%). Finally, one of the last steps in assuring that the reported sensitivity and specificity of a newly developed clinical instrument have more general validity is to apply the receiver operating characteristic methodology, which provides evidence of the optimal levels and ranges of sensitivity and specificity.^{26,27} The authors are to be commended for their application of receiver operating characteristic methodology in the development of the NCCPC-PV.

In closing, it should be noted that there are several lessons to be learned from the article of Breau *et al.*⁶ First, it is always incumbent on investigators who develop new clinical behavioral instruments to specify the characteristics of the scales of measurement they use, as well as the rationale for the statistics that are used in the assessment of the psychometric properties of their instrument. Second, despite this age of increasing technology and specialization, there is a simultaneous and oppositely motivated increased need for cross-disciplinary collaboration to develop state-of-the-art contributions in pain assessment. Sophistication in assessment design is inherent, but this fact is brought to the forefront when

one attempts to develop a valid and reliable pain tool for young and disabled children. Finally, a recent study by Warfield and Kahn²⁸ estimates that more than half of all adult surgical patients experience moderate to severe postoperative pain. It has been stated that accuracy in self-report can improve pain management practices. In disabled children, this option for self-lobbying is almost nonexistent. The American Pain Society in conjunction with the American Academy of Pediatrics states, "Observation of behavior should be used to complement self-report and can be an acceptable alternative when valid self-report is not available."²⁹ Therefore, it is imperative that accurate interpretations of behavior are achieved and assumptions are minimized when validating pain in children. There must be a closing of the gap between clinical assessment and scientific measurement, especially if pain and suffering are to be decimated in the disabled child.

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No Preemptive Analgesia

Is That So Bad?

THE practice of operative anesthesia is an application of Hippocrates' dictum "*primum non nocere*"—first of all, do no harm. A successful anesthetic is one that minimally interferes with the patient's homeostasis and does not add to the unavoidable quotient of surgical trauma. In this context, it is understandable that the notion of preemptive analgesia, by which early application of therapies may diminish later misery, is an enticing grail to pursue. The anesthesiologist's ministrations might then actually improve the patients state, rather than being at best a necessary evil. It is therefore a potential disappointment to conclude, as do Moiniche *et al.*¹ in a detailed meta-analysis published in this issue of *ANESTHESIOLOGY*, that there is little experimental support for a preemptive analgesic effect in clinical settings. They reviewed 80 randomized and blinded studies that compared various analgesic techniques applied before incision and later in the perioperative period. Only modest differences were noted, and these were present only with epidural injections.

The quest to identify a benefit from preinjury analgesic administration for surgical patients has been fueled by repeated and convincing demonstrations of this phenomenon in animals. The reason that a robust experimental finding cannot be confirmed in patients is not forthcoming, but several explanations can be considered. First, sensory blockade may not be adequate during

surgery. The basis of preemptive analgesia is the prevention of increased responsiveness of central nociceptive pathways triggered by intense afferent neural activity. Even very brief sensory events can result in central sensitization,^{2,3} so effective prevention may require continuous sensory ablation throughout the surgical event. The intensity of afferent blockade is also important. Addition of systemic morphine to volatile anesthesia has no preemptive effect,⁴ whereas the more thorough action of intrathecal morphine does prevent central sensitization in rats.⁵ Small doses of intrathecal opioid show no preemptive effect, whereas larger doses have an amplified action given before injury,⁶ presumably through greater efficacy in blocking input from small nonmyelinated C fibers.⁷ The persistence of neuronal traffic, even during successful neuraxial anesthesia,⁸ may limit the preemptive effect of this modality, indicating the importance of thorough regional blockade.⁹ Increased strength of sensory stimulation may overcome the preemptive action of analgesics, even spinal local anesthetic, particularly if inflammation is a component of the injury.¹⁰

Demonstrations of preemptive effects in experimentation on animals have used various types of injuries, including formalin injection and nerve trauma. However, in models that more closely emulate typical clinical surgery, the results are mixed. Spinal hyperexcitability¹¹ and preemptive analgesia¹² are evident in some studies of abdominal surgical injury, but there is no influence of analgesic timing on pain behaviors after peripheral surgery¹³ because of the minimal contribution of central facilitation.¹⁴

The most obvious reason for diverging experimental and clinical findings is that animals may differ substantially from humans in pain pathophysiology and neuropharmacology. In rats, the species with which most studies of preemptive analgesia have been performed, sensitization is readily induced in spinal sensory pathways after conditioning stimuli. A large effect can then be seen when

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intense afferent activity is prevented from reaching the dorsal horn, which may not be the case in other species less prone to sensitization. Because genetic differences, even between various strains of rats, strongly affect the development of neuronal hyperexcitability¹⁵ and hyperalgesia¹⁶ after injury, comparison across species to human injury responses must be suspect.

It is not clear to me that the failure of preemptive analgesia is a great loss in the pragmatic clinical setting. Consider the outcomes used in studies of the topic. The analysis by Møiniche *et al.*¹ tabulates pain scores, supplemental analgesic demand, and time to first postoperative analgesic. Pain scores, while important, should not differ if appropriate care is provided because postoperative pain in the absence of preemptive treatment is nonetheless responsive to adequate doses of analgesia, consistent with electrophysiologic observations in animals.⁶ A difference in supplemental analgesic demand should also not be an important medical issue. The need for 12 mg morphine in the recovery room instead of 4 mg before induction of anesthesia is itself not necessarily problematic. Although increased side effects from larger doses can be expected, there are no data to confirm this suspicion. Finally, a decreased time to first analgesic request in the absence of preemptive analgesia should not be a treatment problem, provided timely medication is available when the need arises.

The challenge, of course, is not to use the least amount of drug, but to minimize complications and optimize postoperative recovery. So far, there is minimal support for the belief that preemptive techniques aid recovery. One promising report confirms a favorable effect of early medication on the incidence and severity of chronic postoperative pain.¹⁷ In future studies of the timing of analgesic agents, it will be helpful to focus on aspects of recuperation, not only on initial postoperative pain levels or analgesic consumption.

Rather than being disappointed, I find the conclusions of Møiniche *et al.*¹ to be encouraging. Trauma patients may be adequately treated with analgesics even though their injury has occurred without pretreatment because an early window of opportunity has not been missed. In scheduled surgery, the various side effects and complications that accompany intraoperative analgesic use may be avoided. For instance, intraoperative administration of opiates may lead to histamine release, dysfunction of the bowel, and disfunction of the biliary and urinary tracts, as well as acute opiate tolerance^{18,19} and hyperalgesia,²⁰ which make postoperative pain treatment more difficult. Epidural local anesthetic block may complicate general anesthesia with hypotension and create diagnostic ambiguity afterward if paresis masks neurologic injury. For these reasons, initiating analgesic care at the time of emergence from general anesthesia may be more desirable; this is also a time when analgesic needs can be directly assessed. Because pain is "an unpleasant

sensory and emotional experience,"²¹ it cannot exist during general anesthesia. If preoperative and intraoperative analgesic treatment has little effect on the long-term course of sensory processes, their use before emergence lacks a clear motive.

There can be little doubt that great benefit will emerge from the burgeoning knowledge of processes underlying pain. Although experimentation may lead to drugs and techniques that can preemptively prevent pain in the clinical setting, our clinical attention must remain on treating pain when it presents, with adequate doses of proven agents.

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