Anesthesiology 2010; 113:175–82

Skin Conductance Fluctuations Correlate Poorly with Postoperative Self-report Pain Measures in School-aged Children

Eugene K. Choo, B.Sc.P.,* William Magruder, M.A.,† Carolyne J. Montgomery, M.D., F.R.C.P.C.,‡ Joanne Lim, M.A.Sc.,§ Rollin Brant, Ph.D.,‖ J. Mark Ansermino, M.B.B.Ch., F.R.C.P.C.#

ABSTRACT

Background: The number of fluctuations of skin conductance per second (NFSC) has been shown to correlate with induced pain and self-report pain scales. This study aimed to evaluate the validity and feasibility of NFSC as an objective measurement of nociception intensity in school-aged children after surgery.

Methods: After approval by the research ethics board and obtaining consent, 100 subjects participated in this prospective observational study. Preoperatively, NFSC was measured for 60 s at rest and during response to a self-report pain scale (numeric rating scale [NRS], Faces Pain Scale-Revised) and anxiety scoring (NRS). Postoperative measurements were repeated every 10 min for 30 min or until NRS pain score was ≤ 4 for two consecutive scores. Spearman rank correlation coefficients were calculated to investigate the relationship between NFSC and NRS pain, Faces Pain Scale-Revised, and NRS anxiety. The clinical utility of using NFSC in determining NRS pain threshold was investigated using receiver operator characteristics analysis. For clinical relevance, a cutoff NFSC was chosen that optimizes both specificity and sensitivity. Although selecting a low cutoff value increases the sensitivity of the NFSC in diagnosing pain, it does so at the expense of specificity.

Results: Data from 90 subjects (64.4% male) aged 7–17 yr (median age 13 yr) were analyzed (217 postoperative datasets). NFSC correlated weakly with NRS pain scores ($P = 0.21$; $P < 0.002$). NFSC did not correlate with NRS anxiety scores ($P = 0.15$, $P < 0.03$). NRS pain scores correlated strongly with Faces Pain Scale-Revised ($P = 0.89$, $P < 0.0001$) and weakly with NRS anxiety scores ($P = 0.34$, $P < 0.0001$). A threshold of 0.23 NFSC predicted severe pain (NRS ≥ 7) with 56.3% sensitivity (95% CI = 37.7–73.6%) and 78.4% specificity (95% CI = 71.7–84.1%). The area under receiver operator characteristic curve for NFSC was 69.1%.

Conclusions: NFSC measurement is feasible in a perioperative setting but was not specific for postoperative pain intensity and was unable to identify analgesia requirements when compared with self-report measures.

What We Already Know about This Topic

- The number of fluctuations of skin conductance (NFSC) correlates with pain self-report in children in some settings, but its utility in school-age children after surgery is unclear

What This Article Tells Us That Is New

- In 90 children, aged 7–17 yr, undergoing surgery, application of the NFSC in the acute postoperative period was feasible but was not specific to postoperative pain intensity

THE difficulties of using self-report measures of pain in verbal children can be significant, because the measures must be age and developmentally appropriate, validated, and sensitive to a child's conceptual and language skills.[1–3] The abil-

Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are available in both the HTML and PDF versions of this article. Links to the digital files are provided in the HTML text of this article on the Journal's Web site (www.anesthesiology.org).

* Medical Student, Faculty of Medicine, ‖ Professor, Department of Statistics, University of British Columbia, Vancouver, British Columbia, Canada. † Writer, ‡ Clinical Professor, § Research Manager, # Assistant Professor, Department of Anesthesiology, Pharmacology, and Therapeutics, University of British Columbia, and British Columbia Children's Hospital, Vancouver, British Columbia, Canada.

Received from the Department of Anesthesiology, Pharmacology and Therapeutics, University of British Columbia, Vancouver, British Columbia, Canada, and British Columbia Children's Hospital, Vancouver, British Columbia, Canada. Submitted for publication October 21, 2009. Accepted for publication March 1, 2010. Support was provided solely from institutional and/or departmental sources. A portion of the present data (on self-report pain scales) was previously reported in: von Baeyer CL, Spagrud LJ, McCormick JC, Choo E, Neville K, Connelly MA: Three new datasets supporting use of the Numerical Rating Scale (NRS-11) for children's self-reports of pain intensity. Pain 2009; 143: 223–7.

Address correspondence to Dr. Montgomery: Pediatric Anesthesiology, British Columbia Children's Hospital, 4480 Oak Street, Vancouver, British Columbia, V6H 3V4 Canada. cmontgomery@cw.bc.ca.

ity to objectively measure nociceptive intensity with an algometric device would be an important advance.

An innovative proprietary skin conductance monitor, the Med-Storm monitor (Med-Storm Innovation AS, Oslo, Norway), has been used to obtain skin conductance data sets in a variety of clinical settings (see figure, Supplemental Digital Content 1, which shows the palmar Med-Storm electrode placement, http://links.lww.com/ALN/A591). This method and the computer analysis used to generate the number of fluctuations of skin conductance per second (NFSC) have previously been described in detail (see figure, Supplemental Digital Content 2, which shows an example of the Med-Storm recording trace, http://links.lww.com/ALN/A592).[4] The device has been used clinically to measure pain in neonates, infants, and children in critical care settings.[5–9]

NFCS may be a promising method of determining postoperative nociceptive intensity.[10,11] NFSC correlated well with self-report postoperative pain measures (0–10 numerical rating scale [NRS]) and was more useful than increases in heart rate or blood pressure in adults. In this study of 25 subjects and 110 data sets, a *post hoc* NFCS rate of 0.1 predicted an NRS greater than 3 with a sensitivity of 89% and specificity of 74%, and it was responsive to analgesic intervention.[10]

The purpose of this study was to evaluate the utility and accuracy of this device for the objective measurement of postoperative pain intensity in school-aged children when compared with self-report pain scales and anxiety scales. In addition, the determination of an optimum sampling window was studied.

Materials and Methods

Study Design and Patients

This was a prospective observational study in a tertiary care pediatric hospital and was approved by the Children's and Women's Hospital and University of British Columbia's Research Review Committee and Research Ethics Board (Vancouver, British Columbia, Canada).

After obtaining consent from the parents and assent from the subjects, we enrolled 100 healthy children aged between 7 and 17 yr. Subjects were considered eligible if they were American Society of Anesthesiologists physical status I or II and if they could understand and perform self-report assessment of pain and anxiety as determined by preoperative assessment.

Before each operation, the Med-Storm Stress Detector was used to measure baseline NFSC for 60 s before administration of the pain and anxiety scales while the subject was resting quietly. NFSC was then measured for an additional 60 s during pain and anxiety scoring. Palmar skin temperature was measured using a temperature probe. State anxiety was measured using an NRS with a technique previously validated in children.[12] A script was followed to ensure consistency of the pain and anxiety intensity tools. Two self-report pain scales, the NRS, and the Faces Pain Scale - Revised (FPS-R) were used to measure baseline pain levels in the preoperative period.[2,13–15] Vital signs consisting of the heart rate (beats/min), systolic blood pressure (mmHg), and respiratory rate (breaths/min) were measured. Parents were present during measurement unless the subject chose to be unaccompanied.

The administration of preoperative anxiolytics and analgesics as well as intraoperative management of the anesthetic was at the discretion of the attending anesthesiologist. Subjects who received anticholinergic or α_2-agonist medications were excluded from the study, similar to the subjects who would receive epidural anesthesia for postoperative pain management.

Postoperatively, the administration of analgesic medications was according to current institutional practice. The number and type of analgesic interventions were recorded. Anxiety was measured using the NRS once the patient was awake.

Vital signs were measured on arrival in the postanesthesia care unit (PACU) and then at 10-min intervals until the subject's pain score was less than or equal to 4. The PACU nurse evaluated the recovery using the standard PACU five-category arousal score.

The NRS and FPS-R pain scales were used to measure pain intensity on the subject's arrival in the recovery room and then every 10 min thereafter until two consecutive pain scores were less than or equal to 4 to a maximum of 20 min. The scales were presented in a consistent order of NRS anxiety, FPS-R, and NRS pain. Analgesia was administered if NRS was more than 4, or at the attending nurse's discretion. NFSC was measured continuously for 60 s, marking 15-s and 30-s intervals with the Med-Storm Stress Detector during each pain and anxiety scoring. Palmar skin temperature was measured. A single researcher (E.C.) collected all data and administered the pain and anxiety scales.

When self-report measures were not possible because of lack of subject cooperation or understanding of the scales postoperatively, data were collected but excluded from comparative analysis.

Statistical Analysis

The power analysis was based on a PACU audit of 171 consecutive patients in 2007.[16] This audit described a pain prevalence of more than 4 in 17% of the population. A sample size of 100 subjects was estimated to provide a power of 80% to detect any correlation greater than 0.30.

Agreement among 15-, 30-, and 60-s sampling intervals was assessed by plotting of the mean difference between two sampling intervals against their mean as described by Bland and Altmann.[17] Spearman rank correlation coefficients were calculated to investigate the relationship between NFSC and NRS pain, FPS-R, and NRS anxiety (all postoperative samples were included). The clinical utility of using NFSC in determining NRS pain threshold was investigated using receiver operator characteristic (ROC) analysis. Optimized threshold values were calculated based on equal sample allocation ratio. Statistical calculations were performed using the computerized statistical program StatsDirect (StatsDirect Ltd., Cheshire, United Kingdom).

Results

Subject Characteristics

One hundred subjects scheduled for day surgery were recruited. Ten subjects were excluded from the analysis. Five received anticholinergic medication, three (aged 7, 11, and 13 yr) were unable to cooperate with pain and anxiety scoring postoperatively, and two were excluded because of MedStorm software errors. The remaining 90 subjects had a median age of 13 yr (range 7–17). There were 58 (64.4%) boys and 32 (35.6%) girls. The procedures included 28 orthopedic, 19 urology, 12 otolaryngology, 7 plastic, 11 general, and 13 other surgeries. The mean duration of anesthesia was 71.6 min (SD = 86.9). Data from all 90 subjects (217 postoperative data sets) were included for analysis. Alternate analysis including only one dataset per subject yielded similar results.

The postoperative palmar skin temperatures were variable (range, 29–33°C) but did not preclude monitoring. Postoperative parental presence was variable based on the sedation score of the child such that most initial scores were done without parental presence and subsequent scores in the presence of the caregiver.

Distribution of Pain Intensity and Reliability of Pain Scoring

The initial postoperative pain scores (NRS) of the 90 subjects were 24 (27%) none, 36 (40%) mild (less than 4), 19 (21%) moderate (greater than or equal to 4 to less than 7), and 11 (12%) severe (greater than or equal to 7) pain. On the basis of the initial postoperative anxiety scores, 36 had none, 27 had mild (less than 4), 21 had moderate (greater than or equal to 4 to less than 7), and 6 had severe anxiety (greater than or equal to 7). Pain and anxiety scores and NFSC paired sets were obtained 217 times postoperatively. The overall pain intensity (NRS) scores were none in 49 (23%), mild in 89 (41%), moderate in 47 (21.5%), and severe in 32 (14.5%) patients. There was a strong correlation between the FPS-R and the NRS for postoperative pain intensity ($P = 0.89$, $P < 0.0001$).

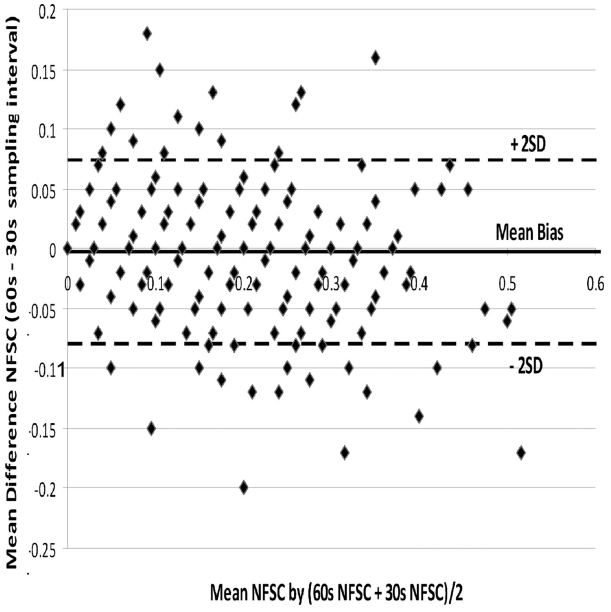

Fig. 1. Bland–Altman plot for comparison of agreement between 60-s and 30-s sampling intervals. y-axis = the difference between a 60-s number of fluctuations of skin conductance (NFSC) sample and corresponding 30-s NFSC sample. x-axis = the mean of a 60-s NFSC sample and corresponding 30-s NFSC sample. The greater the difference between paired samples, the smaller the agreement between measures. N = 430; mean bias = 0; limits of agreement (2 SD of bias) −0.080 to 0.075.

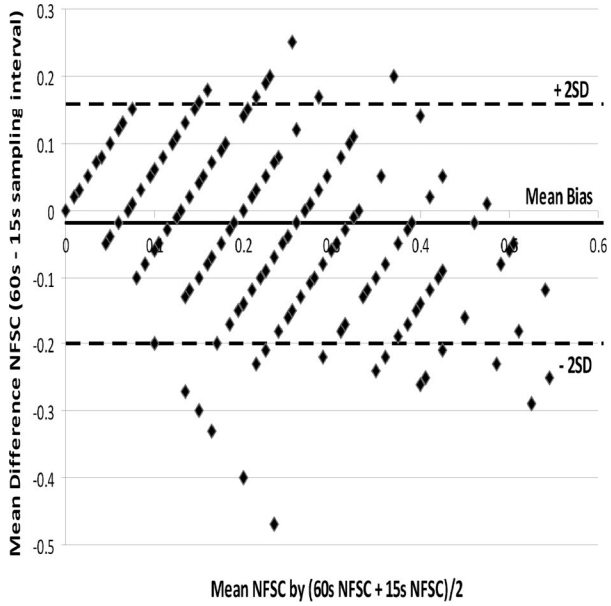

Fig. 2. Bland–Altman plot for comparison of agreement between 60-s and 15-s sampling intervals. y-axis = the difference between a 60-s number of fluctuations of skin conductance (NFSC) sample and corresponding 15-s NFSC sample. x-axis = the mean of a 60-s NFSC sample and the corresponding 15-s NFSC sample. The greater the difference between paired samples, the smaller the agreement between measures. N = 676; mean bias = −0.02; limits of agreement (2 SD of bias) −0.20 to 0.16.

Sampling Interval Analysis

The upper and lower limits of agreement between 60- and 30-s sampling intervals were 0.075 and −0.080 NFSC, respectively (fig. 1). When repeated to compare 60- and 15-s sampling intervals, the limits of agreement were found to be 0.16 and −0.20 NFSC, respectively (fig. 2). On the basis of the sampling interval analysis presented above, a 60-s sampling period was used to generate the values for NFSC.

Skin Conductance and Arousal with Preoperative Participation in Self-report Scoring for Pain and Anxiety

Most subjects (94.5%) showed an increase in NFSC from baseline 60 s after interacting with the investigator during the response to pain and anxiety scoring (fig. 3).

Skin Conductance versus Pain and Anxiety Scores

NFSC was found to correlate weakly with postoperative NRS pain scores ($P = 0.21$, $P < 0.002$). NFSC did not

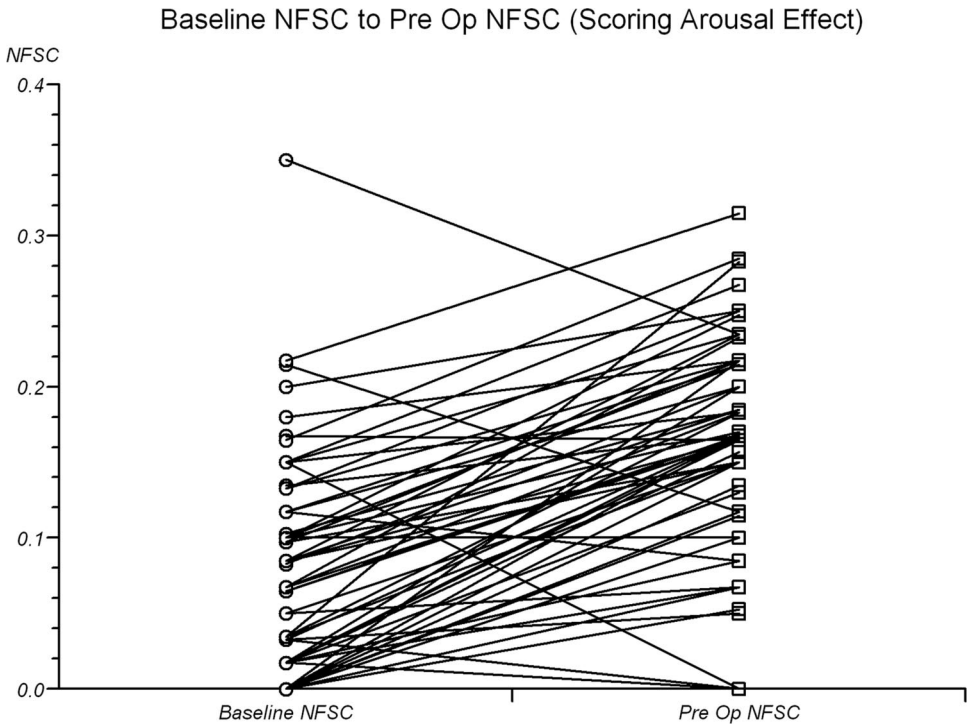

Fig. 3. Change in the number of fluctuations of skin conductance (NFSC) during preoperative testing. NFSC measured while subject was sitting still and quietly for 60 s (baseline NFSC) compared with preoperative NFSC while child was responding to pain or anxiety scores (preop NFSC).

correlate with postoperative NRS anxiety scores ($P = 0.15$, $P < 0.03$). The values of NFSC were not different when pain was categorized as none, mild (less than 4), moderate (greater than or equal to 4 to less than 7), or severe (greater than or equal to 7; fig. 4).

Responsiveness of NFSC to Intravenous Analgesia

Intravenous analgesic rescue was given to 23 subjects. Nineteen of these subjects with NRS greater than 4 and four with FPS-R or NRS less than or equal to 4 received intravenous analgesia as a result of nursing decision. A

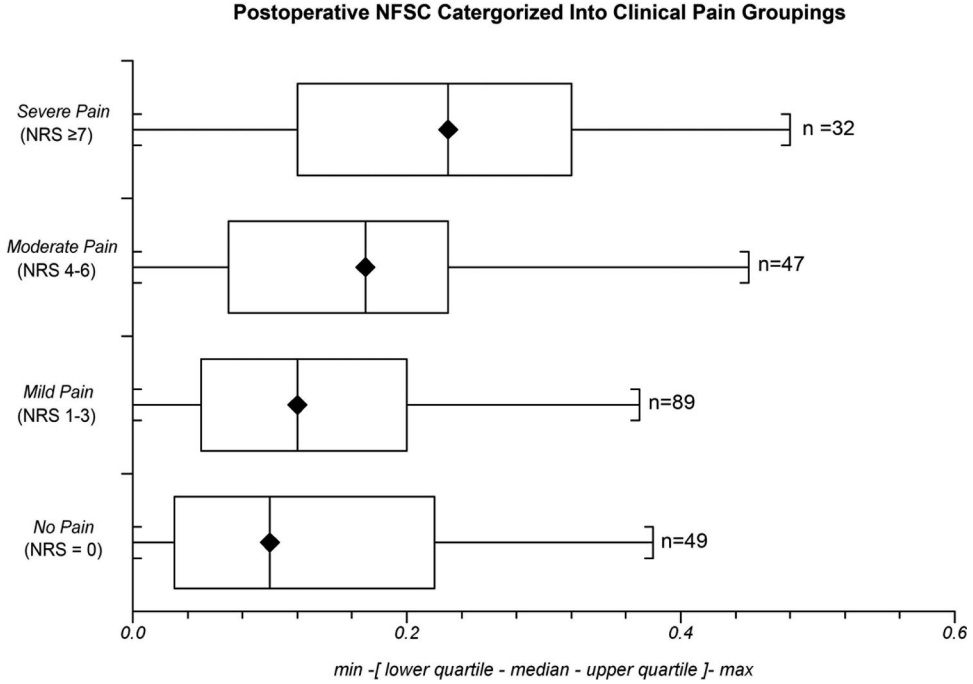

Fig. 4. Postoperative number of fluctuations of skin conductance (NFSC) compared with numeric rating scale (NRS) pain severity categories (217 data sets; NRS pain intensity: 32 severe, 47 moderate, 89 mild, and 49 none).

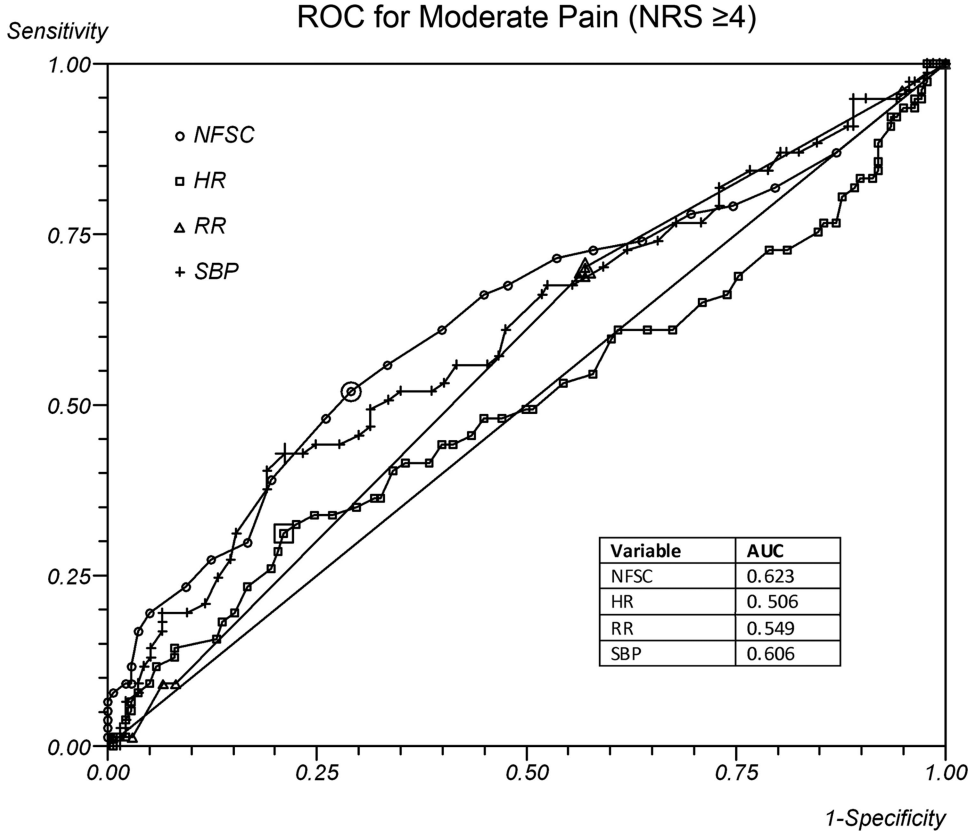

Fig. 5. Receiver operator characteristic (ROC) analysis for moderate pain (numeric rating scale [NRS] greater than or equal to 4) comparing median number of fluctuations of skin conductance (NFSC), mean NFSC, heart rate (HR), systolic blood pressure (SBP), and respiratory rate (RR). AUC = area under the curve.

reduction in NFSC was shown in the 23 subjects who received intravenous analgesia (see figure, Supplemental Digital Content 3, which shows the ROC for moderate pain [NRS greater than or equal to 4] receiving intravenous rescue analgesia, http://links.lww.com/ALN/A593). The pretreatment NFSC was 0.22 (0.23; median [interquartile range]) compared with the posttreatment NFSC at 10 min of 0.15 (0.19) and the lowest posttreatment NFSC of 0.08 (0.19).

ROC Analyses

An ideal diagnostic test would be both 100% specific and 100% sensitive for the desired outcome. Cutoff points can be lowered to increase the sensitivity of the test at the expense of specificity. There is limited utility in a test that is highly sensitive but nonspecific. For clinical relevance, we have chosen to report a cutoff value that optimizes both sensitivity and specificity. This corresponds to the point closest to the upper-left corner of the ROC plot. The area under the curve (AUC) of a ROC curve also provides insight into the performance of a test. An AUC of 1.0 is both 100% specific and 100% sensitive. An AUC of 0.5 is statistically equivalent to a coin toss. An AUC of 0.75 is generally accepted as a clinically relevant test.

The NFSC cutoff point of 0.2 (based on equal weighting of sensitivity and specificity) was able to predict subjects with moderate pain (NFSC greater than or equal to 4) with 51.9% sensitivity (95% CI = 40.4–63.3%) and 71.0% specificity (95% CI = 62.7–78.4%). The AUC of ROC curve for NFSC was 62.3%. This is shown compared with AUC for heart rate, resting rate, and systolic blood pressure (fig. 5).

The cutoff point of 0.23 NFSC was able to predict subjects with severe pain (NFSC greater than or equal to 7) with 56.3% sensitivity (95% CI = 37.7–73.6%), and 78.4% specificity (95% CI = 71.7–84.1%). The AUC of ROC curve for NFSC was 69.1%. This is shown compared with AUC for heart rate, resting rate, and systolic blood pressure (fig. 6).

Discussion

The use of the Med-Storm Stress Detector is feasible in both the preoperative and postoperative assessment of cognitively normal school-aged children. Successful application, functioning, retention of electrode placement, and the use of Med-Storm Stress Detector software for 60-s sampling intervals were possible in a PACU environment in 98% of subjects. The self-report pain intensity scales had a poor correlation with mean NFSC. In severe pain (NRS greater than or equal to 7), there was a low sensitivity but high specificity.

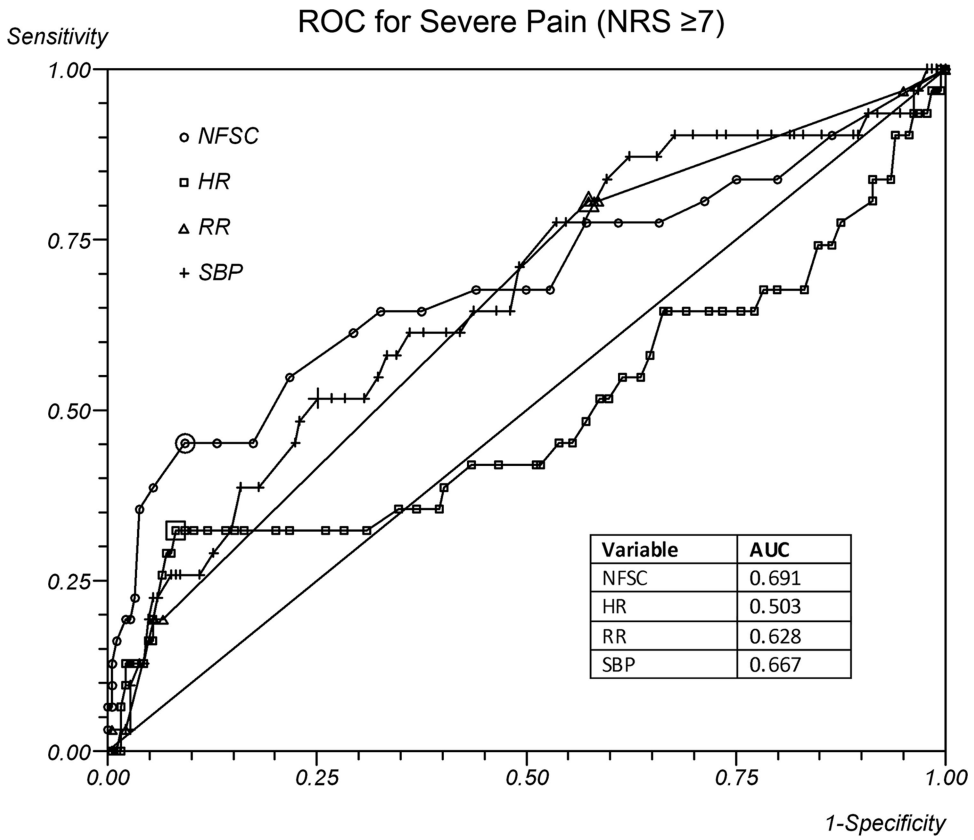

Fig. 6. Receiver operator characteristic (ROC) analysis for severe pain (numeric rating scale [NRS] greater than or equal to 7) comparing median number of fluctuations of skin conductance (NFSC), mean NFSC, heart rate (HR), systolic blood pressure (SBP), and respiratory rate (RR). AUC = area under the curve.

Feasibility

The Med-Storm Stress Detector was sensitive to any type of electrode movement. An increase in NFSC secondary to movement added artifacts that pose a challenge similar to collecting electrophysiologic data such as electrocardiogram and electroencephalographic data. Increased movement is not specific to pain intensity, and many patients with severe pain have diminished spontaneous movement. In addition, anxious or sensory neurologically impaired subjects may also move excessively.

Sampling Interval Analysis and Cutoff Threshold

The ideal duration of the NFSC sampling window has not been previously specified. Previous investigators have evaluated intervals from 5 to 60 s. A window that is too long (more than 60 s) may decrease the clinical utility by increasing the time required to record a measurement. A short (5–7.5 s) interval may miss important fluctuations and increase the risk of contamination by noise, especially if the NFSC is lower. The ideal sampling window should be significantly greater than the time between fluctuations. On the basis of these results, an NFSC sampling window of 60 s was selected. The sampling interval is then larger than the lowest frequency of interest. A sampling window greater than 60 s may improve the results but may be technically more difficult to achieve.

The diagnostic performance is affected by the threshold chosen for classifying subjects with significant pain. A threshold (0.20) that would produce the optimum tradeoff between sensitivity and specificity was identified. Selecting a low-threshold value may result in potentially random fluctuations being interpreted as being clinically important. Although this increases the sensitivity of the NFSC in diagnosing pain, it does so at the expense of specificity. Clinically, this could result in the over-diagnosis of pain, inappropriate analgesic administration, and increased risk of adverse medication effects.

Pain Intensity Measurement

This study has shown that surrogate indicators of pain such as heart rate and blood pressure that are used in composite observation pain scales were neither specific nor sensitive for mild to moderate pain in the PACU setting. Neither NFSC nor traditional physiologic parameters such as heart rate or respiratory rate were sensitive or specific indicators of moderate pain. In severe pain, heart rate was even less predictive than that of moderate pain compared with the NFSC.

Our subjects were selected on the basis of obtaining reliable pediatric subjective pain intensity scores to use as a comparison with the NFSC. The most robust and currently standard metric in this group is a self-report score.[2] The

reliability of the scores was demonstrated by the concordance between the two pain scoring systems (FPS-R and NRS) used and the ability of our subjects to separate anxiety intensity from pain intensity. The study group is not representative of a population that will derive the most benefit from an objective pain intensity measurement device, such as younger children and those with sensory neurologic impairments who are unable to cooperate with self-report scales.

Few subjects (12%) experienced severe pain (greater than or equal to 7), as expected in a tertiary care PACU setting. It would be unethical to alter the study design to generate a higher number of subjects experiencing severe pain.

Predictive Potential

The optimum NFSC threshold for moderate pain, balancing sensitivity and specificity, as determined by ROC analysis, was higher in children than that reported in adults (0.2 *vs.* 0.1). Previous studies on adults have suggested that a *post hoc* threshold value for NFSC of 0.1 at a sampling interval of 15 s was able to discriminate pain scores more than 3. Statistical analysis revealed this cutoff to have a sensitivity of 89% and a specificity of 74%. A second study tested this cutoff value in a larger sample of 75 adults.[10–11] The threshold value was determined to distinguish between patients reporting pain ratings of less than or equal to 3 and those of greater than or equal to 4 (a level indicating the need for further analgesia) with 88.5% sensitivity and 67.7% specificity.[10–11] These previous studies were performed in adults, and the pain categories were lower. A study published after the completion of this study showed that in children aged 8–16 yr, an NFSC cutoff of 0.13 predicted the prevalence of moderate to severe pain with 85.2% specificity and 67.1% sensitivity.[18] Hullet *et al.*[18] chose a lower endpoint that optimized the sensitivity of their measure; however, the AUC of ROC curve remains similar (although not reported). The authors suggested that the poor positive-predictive value of using NFSC as a measurement could be due to the nonspecific nature of the sympathetic skin response. They suggested that NFSC could be influenced by factors other than pain.

Generalized Arousal Response

The variability in postoperative NFSC could potentially be explained by a generalized arousal response. An increase in NFSC was elicited when the subject responded to baseline pain and anxiety scoring (see figure, Supplemental Digital Content 4, which shows a box-and-whiskers plot of median NFSC preoperatively before and during preoperative testing, http://links.lww.com/ALN/A594). The magnitude of this effect has been found to vary depending on the type of interaction between the subject and investigator. A similar effect has been described in infants undergoing nonpainful tactile *versus* painful (heelprick) stimulation.[5]

We minimized the variability in interaction with subjects by ensuring a constant investigator for all data collection. Other variables, such as the presence of the same nurse during the recovery period, continuous parental presence, and the use of a discontinuous category arousal level score, were not standardized in this investigation.

Conclusions

Further work is needed to more fully determine the clinical applicability of the Med-Storm device in the PACU, in other settings such as during surgery, and in more complicated populations such as cognitively impaired children.

The results of this prospective observational study show that although the measurement of NFSC using the Med-Storm Stress Detector is both feasible and practical, the device did not reliably indicate increases in pain intensity in school-aged children postoperatively. The physiologic response elicited by a verbal response to a pain scale was not distinguishable from that produced by postoperative pain.

Hanne Storm, M.D., Ph.D. (Associate Professor, Faculty Division Rikshospitalet, Faculty of Medicine, Rikshospitalet University Hospital, Oslo, Norway), and Thomas Ledowski, M.D. (Professor, School of Medicine and Pharmacology, The University of Western Australia, Perth, Western Australia, Australia, and Department of Anaesthesiology and Intensive Care Medicine, University of Schleswig Holstein, Lubeck, Germany), contributed their experiences with the use of the Med-Storm device (Med-Storm Innovation AS, Oslo, Norway). Carl von Baeyer, Ph.D., R.D.Psych. (Emeritus Professor of Psychology and Associate Member in Pediatrics, Department of Psychology, University of Saskatchewan, Saskatoon, Saskatchewan, Canada), contributed his expertise in the choice and clinical use of the anxiety and pain rating scales, data management, and presentation. The perioperative nursing staff (British Columbia Children's Hospital, Vancouver, British Columbia, Canada) was most cooperative with all clinical aspects of this study.

References

1. McGrath PJ, Frager G: Psychological barriers to optimal pain management in infants and children. Clin J Pain 1996; 12:135–41
2. Stinson JN, Kavanagh T, Yamada J, Gill N, Stevens B: Systematic review of the psychometric properties, interpretability and feasibility of self-report pain intensity measures for use in clinical trials in children and adolescents. Pain 2006; 125:143–57
3. Merkel SI, Voepel-Lewis T, Shayevitz JR, Malviya S: The FLACC: A behavioral scale for scoring postoperative pain in young children. Pediatr Nurs 1997; 23:293–7
4. Storm H: Changes in skin conductance as a tool to monitor nociceptive stimulation and pain. Curr Opin Anaesthesiol 2008; 21:796–804
5. Eriksson M, Storm H, Fremming A, Schollin J: Skin conductance compared to a combined behavioural and physiological pain measure in newborn infants. Acta Paediatr 2008; 97:27–30
6. Harrison D, Boyce S, Loughnan P, Dargaville P, Storm H, Johnston L: Skin conductance as a measure of pain and stress in hospitalised infants. Early Hum Dev 2006; 82:603–8
7. Hellerud BC, Storm H: Skin conductance and behaviour during sensory stimulation of preterm and term infants. Early Hum Dev 2002; 70:35–46
8. Hernes KG, Morkrid L, Fremming A, Odegarden S, Martinsen OG, Storm H: Skin conductance changes during the first year of life in full-term infants. Pediatr Res 2002; 52:837–43
9. Gjerstad AC, Wagner K, Henrichsen T, Storm H: Skin

conductance *versus* the modified COMFORT sedation score as a measure of discomfort in artificially ventilated children. Pediatrics 2008; 122:e848–53

10. Ledowski T, Bromilow J, Paech MJ, Storm H, Hacking R, Schug SA: Monitoring of skin conductance to assess postoperative pain intensity. Br J Anaesth 2006; 97:862–5
11. Ledowski T, Bromilow J, Wu J, Paech MJ, Storm H, Schug SA: The assessment of postoperative pain by monitoring skin conductance: Results of a prospective study. Anaesthesia 2007; 62:989–93
12. Crandall M, Lammers C, Senders C, Savedra M, Braun JV: Initial validation of a numeric zero to ten scale to measure children's state anxiety. Anesth Analg 2007; 105:1250–3
13. Gagliese L, Weizblit N, Ellis W, Chan VW: The measurement of postoperative pain: A comparison of intensity scales in younger and older surgical patients. Pain 2005; 117:412–20
14. Hicks CL, von Baeyer CL, Spafford PA, van Korlaar I, Goodenough B: The Faces Pain Scale-Revised: Toward a common metric in pediatric pain measurement. Pain 2001; 93:173–83
15. Caldwell-Andrews AA, Blount RL, Mayes LC, Kain ZN: Behavioral interactions in the perioperative environment: A new conceptual framework and the development of the perioperative child-adult medical procedure interaction scale. ANESTHESIOLOGY 2005; 103:1130–5
16. Trudeau JD, Lamb E, Gowans M, Lauder G: A prospective audit of postoperative pain control in pediatric patients. AORN J 2009; 90:531–42
17. Bland JM, Altman DG: Statistical methods for assessing agreement between two methods of clinical measurement. Lancet 1986; 1:307–10
18. Hullett B, Chambers N, Preuss J, Zamudio I, Lange J, Pascoe E, Ledowski T: Monitoring electrical skin conductance: A tool for the assessment of postoperative pain in children? ANESTHESIOLOGY 2009; 111:513–7

ANESTHESIOLOGY REFLECTIONS

Mariani's Coca Plant

In 1863 a Corsican native named Angelo Mariani (1838–1914) became one of France's most famous and wealthy chemists by concocting a "coca wine" that would be marketed worldwide as "Vin Mariani." Hailed as a panacea by thousands of leading physicians, this cocaine-and-Bordeaux tonic was even publicly endorsed from London by Queen Victoria and from Rome by at least two Popes. One of Mariani's many coca-inspired illustrations is this example (*above,* courtesy of the Wood Library-Museum), his *Reproduction of a Coca Plant Presented by Mr. Mariani to the Paris Botanical Gardens*. His Vin Mariani would inspire the development of America's leading cocaine tonic, Coca Cola. (Copyright © the American Society of Anesthesiologists, Inc. This image appears in color in the *Anesthesiology Reflections* online collection available at www.anesthesiology.org.)

George S. Bause, M.D., M.P.H., Honorary Curator, ASA's Wood Library-Museum of Anesthesiology, Park Ridge, Illinois, and Clinical Associate Professor, Case Western Reserve University, Cleveland, Ohio. UJYC@aol.com.