

# Pain assessment in the critically ill mechanically ventilated adult patients: Comparison between skin conductance algesimeter index and physiologic indicators

## ABSTRACT

**Background and Objectives:** Critically ill patients are unable to communicate effectively, so it is difficult to assess their pain and analgesic requirement. Skin conductance algesimeter (SCA) index is a device that primarily measures changes in skin conductance real time to assess pain.

**Methods:** We planned this quantitative prospective observational study to assess pain in the critically ill mechanically ventilated patients in comparison to physiologic indicators such as blood pressure and heart rate. A repeated measures design was chosen, and a sample size of 180 was taken from 60 patients with sepsis, acute exacerbations of chronic obstructive pulmonary disease, community-acquired pneumonia, and postsurgical patients in the Intensive Care Unit (ICU). The two painful procedures chosen were tracheal suction and patient positioning. The data were collected at rest, at tracheal suctioning, 20 min later at positioning of the patient, and final reading 20 min later. Three testing periods, each including 4 assessments for a total of 12 pain assessments with sixty patients, were completed during each patient's ICU course. A total of six assessments were done with the patient at rest and three each with pain stimulus of tracheal suctioning and patient positioning.

**Results:** There was a significant increase in both hemodynamic variables during painful procedures except for the heart rate during positioning. The correlation between the SCA index and Ramsay scale was negative and significant.

**Conclusions:** This instrument might prove useful to measure pain in uncommunicative critically ill patients and to evaluate the effectiveness of analgesic treatment and adapt it.

**Key words:** Intensive Care Unit; pain; skin conductance algesimeter index

## Introduction

Pain assessment for critically ill patients, especially for nonverbal patients, continues to present a challenge for clinicians and researchers.<sup>[1-4]</sup> Critically ill patients are unable to communicate effectively due to tracheal intubation,

reduced level of consciousness, sedation, and administration of neuromuscular blocking drugs.<sup>[5-7]</sup> When patients cannot verbally communicate the pain, as is the case for infants, patients in general anesthesia, and patients in Intensive Care Unit (ICU), there exists no gold standard for pain assessment.

This is an open access article distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as the author is credited and the new creations are licensed under the identical terms.

**For reprints contact:** reprints@medknow.com

**How to cite this article:** Khanna P, Chandralekha C, Pandey RK, Sharma A. Pain assessment in the critically ill mechanically ventilated adult patients: Comparison between skin conductance algesimeter index and physiologic indicators. *Saudi J Anaesth* 2018;12:204-8.

Access this article online	
<b>Website:</b> <a href="http://www.saudija.org">www.saudija.org</a>	<b>Quick Response Code</b> 
<b>DOI:</b> 10.4103/sja.SJA_489_17	

## PUNEET KHANNA, CHANDRALEKHA CHANDRALEKHA, RAVINDER KUMAR PANDEY, ANKUR SHARMA<sup>1</sup>

Department of Anaesthesiology, Pain Medicine and Critical Care, All India Institute of Medical Sciences, New Delhi, <sup>1</sup>Department of Anaesthesiology and Critical Care, All India Institute of Medical Sciences, Jodhpur, India

**Address for correspondence:** Dr. Ravinder Kumar Pandey, Department of Anaesthesiology, Pain Medicine and Critical Care, Room No. 5013, 5<sup>th</sup> Floor Teaching Block, All India Institute of Medical Sciences, Ansari Nagar, New Delhi - 110 029, India.  
 E-mail: ravindrapandey1972@gmail.com

A fast-reacting, objective, sensitive, specific, continuous, and online method to monitor pain individually is therefore needed.

Emotional sweating is activated through skin sympathetic nerves and is not influenced by environmental temperatures within normal range, but from the cerebral cortex. Each time the skin sympathetic nervous system is activated, the palmar and plantar sweat glands are filled up. The skin resistance is reduced, and skin conductance increases before the sweat is reabsorbed and skin conductance again decreases. This creates a skin conductance peak, and the size of the peak depends on how forcefully the skin sympathetic nerve is firing.<sup>[8,9]</sup> The skin conductance peak is specific for the stimulus, which induces the response and is evident within 1–2 s after stimulation.<sup>[10]</sup> The skin sympathetic nerves release acetylcholine that acts on muscarine receptors and is therefore not influenced by neuromuscular blockade, adrenergic receptor active agents, or changes in blood volume. Med-Storm's skin conductance algesimeter (SCA) is used to measure pain by analyzing changes in skin conductance.<sup>[10]</sup> The SCA is a device that primarily measures changes in skin conductance real time to assess pain in the patient. A skin conductance peak is defined as a minimum followed by a maximum in conductance values (mS). From the skin conductance peak, peaks per second and the relative area under the curve can be calculated online and used for pain assessment, typically analyzed in a sliding 15 s windows updated each second. The measurement is performed using three self-adhesive electrodes, denoted C (current), R (reference), and M (measurement) attached to palmar or plantar skin. The measurement unit uses the C and R electrodes in a feedback configuration to apply an exact and constant alternating voltage between the R and M electrodes. The return current from the M electrode is recorded, as its value provides direct information on the skin conductance. The recorded alternating current signal is subjected to advanced filtering which removes noise and interference before the signal is sent onto the display computer.<sup>[10]</sup>

We hypothesized that skin conductance algesimeter index (SCAI) may have sufficient accuracy to assess pain in the critically ill mechanically ventilated patients in comparison to physiologic indicators such as blood pressure (BP) and heart rate (HR) and has the potential to significantly improve pain treatment practices. To test this hypothesis, we compared pain assessment from the SCA with those derived and analyzed from physiologic parameters. We hypothesized that if the SCAI really measures pain, the SCAI should be much higher during painful procedures than while the patient is at rest.

## Methods

A repeated measures design was chosen for this quantitative prospective observational study. A sample size of 180 from 60 patients in the ICU at AIIMS, New Delhi, was recruited for the study after Institutional Ethics Committee approval.

In the ICU, patients of more than 16 years of age of both sexes requiring tracheal intubation and mechanical ventilation were included in the study. If patients were shifted to ICU without a tracheal intubation, they were not considered eligible for the study. However, if they required tracheal intubation and mechanical intubation in the first 48 h of admission of ICU, they were recruited for the study. Patients were excluded if they were quadriplegic, receiving neuromuscular blocking medications, or had a peripheral neuropathy, pregnancy, morbid obesity, received medical treatment for chronic pain, an ejection fraction <25%, preexisting psychiatric or neurological problems, dependence on alcohol or drugs, received neuromuscular blockers following surgery, or had complications after surgery such as hemorrhage and delirium. The study was explained to eligible patient's relatives, and informed consent was obtained. The assessments of the study parameters were done in the first 48 h after tracheal intubation or if they were received in the ICU with tracheal tube *in situ*.

In addition to the SCAI (Med-Storm's SCA, Medstorm Innovation As, Gimle Terassi 4-0264OSLO, Norway), invasive arterial BP and HR (from electrocardiography) were also collected, using multimodal monitors. For each patient, the SCAI and the two physiological variables were collected three times (morning, afternoon, and night). Evaluation of the SCAI and the physiological variables was made at rest and during painful procedures to appreciate the SCAI responsiveness. The two painful procedures chosen were tracheal suction and patient positioning (defined as movement during shifting of the patient in bed). The data were collected at rest, at tracheal suctioning, 20 min later at positioning of the patient, and final reading 20 min later. They were selected because their painful characters had been demonstrated in several previous studies and because they were part of the routine care that was normally planned for the patients.<sup>[11-13]</sup> The patients would be grouped in four based on number of fluctuations. The number of fluctuations of skin conductance per second was different between patients with no (0.07) (Group 1), mild (0.16) (Group 2), moderate (0.28) (Group 3), and severe pain (0.33) (Group 4).<sup>[14]</sup>

The patient received sedation as per institutional protocol using morphine and midazolam infusions. The patients' sedation levels were assessed using the Ramsay scale.<sup>[12]</sup> The

Ramsay scale rates sedation level on a scale from 1 to 6. The level of sedation was kept as Ramsay sedation score of >3.

This was pilot study of sixty patients to assess the relationship between SCIA and physiological parameters in response to painful activity. There is no published literature to assess for formal sample size, and hence, sample size of sixty was considered as sample of convenience. The statistical test was applied to the observed parameters. The data are summarized as mean ± standard deviation. The correlations between the studied parameters were analyzed using Pearson correlation coefficient. *P* < 0.05 was considered statistically significant.

### Results

Three testing periods, each including 4 assessments for a total of 12 pain assessments with sixty patients, were completed during each patient’s ICU course. A total of six assessments were done with the patient at rest, and three each with pain stimulus of tracheal suctioning and patient positioning. The patient population included a variety from those in sepsis, with acute exacerbations of chronic obstructive pulmonary disease, community-acquired pneumonia, postsurgical, and other cases [Table 1].

There was a significant increase in both hemodynamic variables during painful procedures except for the heart rate during positioning [Tables 2 and 3].

The correlation between the SCIA and Ramsay scale was negative and significant [Figure 1]. The logical direction of the association is the higher the sedation level, the lower the ability to express painful behaviors [Tables 4 and 5].

### Discussion

Pain is one of the complaints of the patients admitted in ICU. The pain intensity varies with associated disease and also related to invasive procedures being performed over them in ICU. It has been reported that 29% of patients remembered pain in ICU, especially after invasive procedures.<sup>[15]</sup> Another study reported an occurrence of severe pain in 63% of the surgical patients.<sup>[16]</sup> All ICU patients require optimal pain medication. However, the correct dose of analgesics and sedative agents are essential. The high doses of analgesics and sedatives for the treatment of pain and anxiety have been associated to delirium, a predictor for death and prolonged need for ventilation. Some patients who recover from critical illness may suffer from long-term psychological disturbance such as posttraumatic stress disorder, anxiety, or depression. Various assessment tools have been used for assessment of

**Table 1: Patient demographic profile (n=180)**

Parameters	Values
Age (year)	43.7 ± 19.3
Weight (kg)	60.6 ± 13.9
Sex (male:female)	100:80
Mean Ramsay sedation score	3.6 ± 1.6
Diagnostic categories	
Sepsis	16
Postoperative	21
COPD	6
CAP/aspiration/ARDS	8
Others	9

Values expressed as means ± SD. SD: Standard deviation; COPD: Chronic obstructive pulmonary disease; CAP: Community-acquired pneumonia; ARDS: Acute respiratory distress syndrome

**Table 2: Study parameters: physiological variables and skin conductance algesimeter index at rest and during tracheal suctioning (n=180)**

Parameter	SBP	DBP	HR	SCAI
Rest	117.7 ± 19.9	72.2 ± 11.8	102.6 ± 20.2	0
After tracheal suctioning	128.2 ± 20.6	81.1 ± 11.9	111.1 ± 20.0	0.3506 ± 0.2429
<i>P</i> value	<0.001	<0.001	<0.001	<0.001

Values expressed as means ± SD. SCAI: Skin conductance algesimeter index; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; HR: Heart rate; SD: Standard deviation

**Table 3: Study parameters: physiological variables and skin conductance algesimeter index at rest and patient positioning**

Parameter	SBP	DBP	HR	SCAI
Rest	119.6 ± 20.0	75.7 ± 12.2	108.9 ± 77.5	0
After patient positioning	130.6 ± 20.8	83.4 ± 12.3	112.8 ± 20.3	0.346 ± 0.2811
<i>P</i> value	<0.001	<0.001	0.517	<0.001

Values expressed as means ± SD. SCAI: Skin conductance algesimeter index; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; HR: Heart rate; SD: Standard deviation

pain and sedation in ICU. Acute pain assessment scores based on behavioral state and physiological responses in critically ill ICU patients are influenced by sedatives and neuromuscular blockade.

We used hemodynamic parameters of BP and HR as a marker of pain. We have chosen these two hemodynamic variables as previous studies had shown that increased heart rate and increased arterial BP are the most frequently used physiological indicators for pain assessment.<sup>[11]</sup> In hemodynamically unstable patients, the rationale for using hemodynamic measures to monitor noxious stimuli is questionable. However, it is agreed that these physiological indicators lack specificity in the ICU and can be influenced by many medications (vasopressors, adrenergic blockers, anti-arrhythmics, and sedative drugs) and pathological

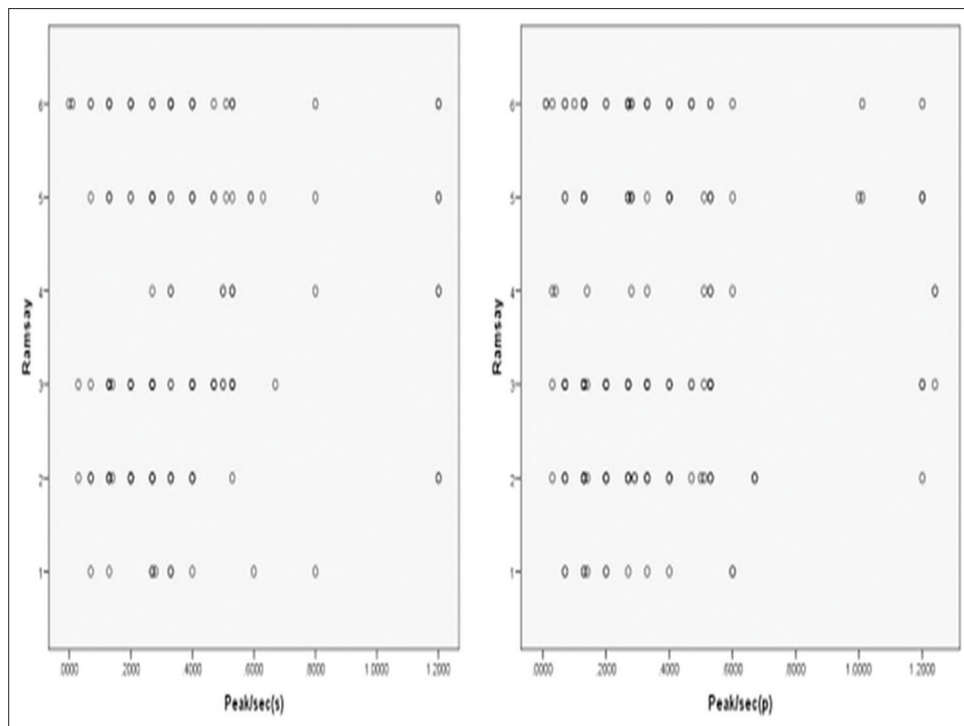


Figure 1: Correlation between Ramsay score and skin conductance algesimeter index during tracheal suctioning and positioning

Table 4: Skin conductance algesimeter index at rest, during tracheal suctioning, and patient positioning

Pain	Group	Frequency (%)
<b>Tracheal suctioning (n=180)</b>		
No pain	1	3 (1.7)
Mild pain	2	31 (17.2)
Moderate pain	3	58 (32.2)
Severe pain	4	88 (48.9)
<b>Patient positioning (n=180)</b>		
No pain	1	8 (4.4)
Mild pain	2	47 (26.1)
Moderate pain	3	36 (20.0)
Severe pain	4	89 (49.5)

Table 5: Correlation between skin conductance algesimeter index and physiological parameters (n=180)

Group	Pearson correlation	Significant (two-tailed)
Change in SBP (patient positioning)	-0.002	0.984
Change in SBP (tracheal suctioning)	0.182	0.15
Change in DBP (patient positioning)	-0.125	0.095
Change in DBP (tracheal suctioning)	0.016	0.836
Change in heart rate (patient positioning)	0.088	0.241
Change in heart rate (tracheal suctioning)	-0.005	0.943

SBP: Systolic blood pressure; DBP: Diastolic blood pressure

conditions (sepsis, shock, hypoxia, and fear).<sup>[17]</sup> Moreover, no significant correlation was found among the SCAI index and the two physiological variables in our study.

The SCA index has low interindividual variability, reacts immediately, and gives objective and continuous online reading specifically linked to the individual. Studies have demonstrated high sensitivity and specificity in detecting pain and nociceptive stimulation. The SCA monitors directly the emotional part of the sympathetic nervous system and is not influenced by hemodynamic changes, adrenergic-acting agents, or by neuromuscular blockade. The SCA may be an important tool for tailoring the use of analgesics administration to reduce pain in ICU as well as its complication.

The SCAI is more sensitive and specifically linked to pain and noxious stimuli because there is no influence by circulatory changes, cardioactive or vasoactive drugs, and neuromuscular blockade. The SCAI reacts within seconds and is specific for the individual, continuous, objective, and more sensitive and specific for assessing pain than other currently available methods during emergence from anesthesia, and the SCA reacts similarly to the EEG monitors, bispectral index, and state entropy.<sup>[17]</sup> The number of fluctuations of skin conductance per second was different between patients with no (0.07) (Group 1), mild (0.16) (Group 2), moderate (0.28) (Group 3), and severe pain (0.33) (Group 4); this was adapted from the previous study.<sup>[14]</sup>

It has been reported that SCA index could detect the noxious stimulation from tracheal suctioning in artificially

ventilated children better than invasive arterial BP and HR when the COMFORT sedation score was used in hemodynamically stable patients.<sup>[10]</sup> The SCA might, therefore, be a more sensitive and specific tool to measure noxious stimuli in critically ill patients than other available methods.

## Conclusions

The present study provides evidence that the SCA has good properties for detecting pain. This instrument might prove useful to measure pain in uncommunicative, critically ill patients and to evaluate the effectiveness of analgesic treatment and adapt it. Further studies are required to determine whether the use of this SCAI can really improve management of pain in the critical care setting.

## Financial support and sponsorship

Nil.

## Conflicts of interest

There are no conflicts of interest.

## References

- Puntillo KA. Dimensions of procedural pain and its analgesic management in critically ill surgical patients. *Am J Crit Care* 1994;3:116-22.
- Puntillo K, Weiss SJ. Pain: Its mediators and associated morbidity in critically ill cardiovascular surgical patients. *Nurs Res* 1994;43:31-6.
- Puntillo KA, White C, Morris AB, Perdue ST, Stanik-Hutt J, Thompson CL, *et al.* Patients' perceptions and responses to procedural pain: Results from thunder project II. *Am J Crit Care* 2001;10:238-51.
- Whipple JK, Lewis KS, Quebbeman EJ, Wolff M, Gottlieb MS, Medicus-Bringa M, *et al.* Analysis of pain management in critically ill patients. *Pharmacotherapy* 1995;15:592-9.
- Bosenberg A, Thomas J, Lopez T, Kokinsky E, Larsson LE. Validation of a six-graded faces scale for evaluation of postoperative pain in children. *Paediatr Anaesth* 2003;13:708-13.
- Rodriguez CS, McMillan S, Yarandi H. Pain measurement in older adults with head and neck cancer and communication impairments. *Cancer Nurs* 2004;27:425-33.
- Guignard B. Monitoring analgesia. *Best Pract Res Clin Anaesthesiol* 2006;20:161-80.
- Wallin BG. Sympathetic nerve activity underlying electrodermal and cardiovascular reactions in man. *Psychophysiology* 1981;18:470-6.
- Storm H. Skin conductance and the stress response from heel stick in preterm infants. *Arch Dis Child Fetal Neonatal Ed* 2000;83:F143-7.
- Storm H. Changes in skin conductance as a tool to monitor nociceptive stimulation and pain. *Curr Opin Anaesthesiol* 2008;21:796-804.
- Puntillo KA, Miaskowski C, Kehrle K, Stannard D, Gleeson S, Nye P, *et al.* Relationship between behavioral and physiological indicators of pain, critical care patients' self-reports of pain, and opioid administration. *Crit Care Med* 1997;25:1159-66.
- Ramsay MA, Savege TM, Simpson BR, Goodwin R. Controlled sedation with alphaxalone-alphadolone. *Br Med J* 1974;2:656-9.
- Vaghadia H, al-Ahdal OA, Nevin K. EMLA patch for intravenous cannulation in adult surgical outpatients. *Can J Anaesth* 1997;44:798-802.
- Ledowski T, Bromilow J, Wu J, Paech MJ, Storm H, Schug SA, *et al.* The assessment of postoperative pain by monitoring skin conductance: Results of a prospective study. *Anaesthesia* 2007;62:989-93.
- Playfor S, Thomas D, Choonara I. Recollection of children following intensive care. *Arch Dis Child* 2000;83:445-8.
- Puntillo KA, Stannard D, Miaskowski C, Kehrle K, Gleeson S. Use of a pain assessment and intervention notation (P.A.I.N.) tool in critical care nursing practice: Nurses' evaluations. *Heart Lung* 2002;31:303-14.
- Hamill-Ruth RJ, Marohn ML. Evaluation of pain in the critically ill patient. *Crit Care Clin* 1999;15:35-54, v-vi.

## Staying in touch with the journal

### 1) Table of Contents (TOC) email alert

Receive an email alert containing the TOC when a new complete issue of the journal is made available online. To register for TOC alerts go to [www.saudija.org/signup.asp](http://www.saudija.org/signup.asp).

### 2) RSS feeds

Really Simple Syndication (RSS) helps you to get alerts on new publication right on your desktop without going to the journal's website. You need a software (e.g. RSSReader, Feed Demon, FeedReader, My Yahoo!, NewsGator and NewzCrawler) to get advantage of this tool. RSS feeds can also be read through FireFox or Microsoft Outlook 2007. Once any of these small (and mostly free) software is installed, add [www.saudija.org/rssfeed.asp](http://www.saudija.org/rssfeed.asp) as one of the feeds.