Extended Abstract

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The Capability of Skin Conductance to Monitor Pain Compared to Other Physiological Pain Assessment Tools in Children and Neonates

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Background: In some European countries and the US it is mandatory to assess and treat pain. In Pubmed there are more than 240 papers when searching for "skin conductance" and "pain".

Aims: The aim is to review the utility of the skin conductance responses (SCR)/sec to assess pain in infants and children.

Study design: Two searches in Pubmed, where one includes the key words "skin conductance", "pain", and "children". Search two included "skin conductance", "pain", and "infants". The finds in these searches are discussed and compared with other physiological pain assessment tools.

Outcome measures: Search one; regarding children, included twelve papers, and search two, regarding infants, included 20 papers.

Results: All the found papers show that the SCR/sec increases during defined painful procedures. Postoperatively, at intensive care units, and at neonatal units, the SCR/sec shows high sensitivity to monitor pain, but a lower specificity. The the SCR/sec is the most accurate means to assess pain when compared to the HR and peripheral oxygen saturation.

Keywords: Heart rate; Pain; Peripheral oxygen saturation; Physiological pain assessment tool; Skin Conductance responses

Abbreviations: HR: Heart Rate; SCR: Skin Conductance Responses; bpm: Beats Per Minute; ECG: Electro Cardio Graphi; HRV: Heart Rate Variability; JCAHO: Joint Commission on Accreditation of Healthcare Organizations; NIRS: Near Infrared Spectroscopy; NFCS: Neonatal Facial Coding System; NIDCAP: Newborn Individualized Developmental Care and Assessment Program

Introduction: In 2001, the Joint Commission on Accreditation of Healthcare Organizations (JCAHO), US, introduced standards which require pain assessment and treatment. In addition to blood pressure, heart rate, respiration, and temperature, pain was defined as the fifth vital sign. Even though the patient's satisfaction with pain management has increased on a general level, increased incidences of opioid-associated adverse drug reactions with the potential of a fatal outcome have been reported. Similar guidelines showing the importance of monitoring and treating pain are about to be established in France, Italy, and Russia.

The definition of pain is "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage". Children below three years of age have difficulties in communicating their pain verbally. Neonates and children below three years of age are the most challenging groups in which we assess pain.

For a long time one has believed that neonates did not perceive pain due to neurological immaturity. On several occations new-borns did not receive analgesic or anaesthetic medication during pain inducing procedures, e.g. surgery. Compared to older children and adults, lower pain thresholds have been found in preterm infants. This is probably due to the absence of inhibitory descending spin thalamic fibres. The way in which the preterm infant perceives pain may be immature at birth; however, it is believed that preterm infants are able to perceive pain [1]. Treatment of pain in neonates which is not satisfac-

tory has both short-term and long-term side effects. After exposure to noxious or painful stimuli changes in behavioural, hormonal, and metabolic parameters as well as other physiological variables are observed. These factors may possibly be linked to an increased occurrence of postoperative complications and even deaths. Deeper anaesthesia reduced severe outcomes such as sepsis and mortality after surgery. Respiratory-distressed neonates receiving pain relief during tracheal suction and routine procedures improved their oxygenation [1]. An increase in intracranial pressure after painful procedures which may result in severe intraventricular haemorrhage has been suggested in preterm infants [2]. When circumcised boys had their vaccination months later, they showed a stronger pain response compared to infants who were not circumcised. This is possibly due to sensitisation [3].

Infants should also be protected against non-invasive stressful routine procedures because similar side effects as the ones which are seen during painful procedures may occur [4].

Interestingly, long term side effects of children suffering acute pain after surgery do not develop into chronic pain as often observed in adults [5]. This phenomenon is possibly due to physiological as well as psychological factors. It has been suggested that the plasticity in the nervous system reduces the risk of developing chronic pain.

Both behavioral and physiological pain assessment tools are non specific to pain [6]. Caregivers must therefore use their clinical judgment in understanding why the infant is in distress. If an ongoing stimulus occurs, the emotional stress response is very likely to be caused by this stimulus. Thus the treatment should focus on reducing the stimulus that has induced the distress, or treat the symptoms according to the origin of the stimulus. Behavioural pain assessment tools are often used in infants [6]. Physiological pain assessment tools should be used in infants exposed to hypothermia, infants exposed to a number of previous painful procedures, as well as patients who are critically ill or sedated [1,7]. These physiological pain assessment tools should also be applied regarding patients where real time pain assessment is required. In infants below 28 weeks of gestational age a physiological pain assessment tool, skin conductance responses (SCR)/sec, is to be preferred when measuring levels of pain [7]. When searching for “skin conductance” and “pain” in Pubmed there are more than 240 papers to be found.

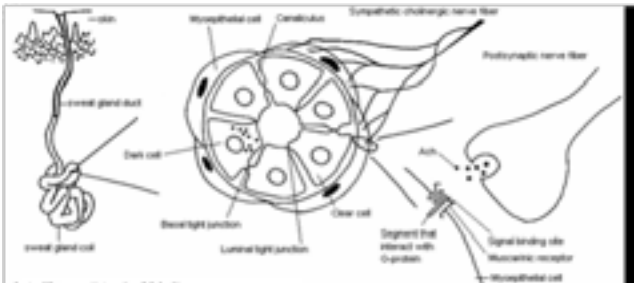
The objective of this review is to focus on the utility of the skin conductance responses (SCR0/sec to assess pain in infants and children. Furthermore, the finds will be discussed and compared with other physiological pain assessment tools.

Method: This review is based on two searches in Pubmed. Search one includes the key words “skin conductance”, “pain”, and “children”. Search two includes the key words “skin conductance”, “pain”, and “infants”. The findings in these searches are discussed and compared with other physiological pain assessment tools.

Results: Search one, with respect to kids, included twelve papers of which five demonstrated the SCR/sec during agonizing methods or after observational agony scores were utilized. Just one of these examinations analyzed the SCR/sec during agonizing/distress methodology, and the SCR/sec expanded and related with the COMFORT sedation score. In the other of these examinations the affectability and explicitness of SCR/sec were determined in the postoperative setting, with various cutoff esteems for the SCR/sec to find moderate and serious torment, and distinctive breaking down windows. Cut off estimation of 0.13 SCR/sec to find moderate and extreme torment and 15 sec breaking down window indicated the best outcomes , and are likewise suggested from the manufactor (www.med-storm. com). Among the other seven, one paper demonstrated skin conductance movement during skin illness, another indicated skin conductance action during the enthusiastic worry of introduction, a third paper demonstrated skin conductance action during Pavlovian condition reflex, and a fourth paper demonstrated skin conductance action in grown-ups. The staying three investigations indicated skin conductance movement during excruciating methods, be that as it may, the

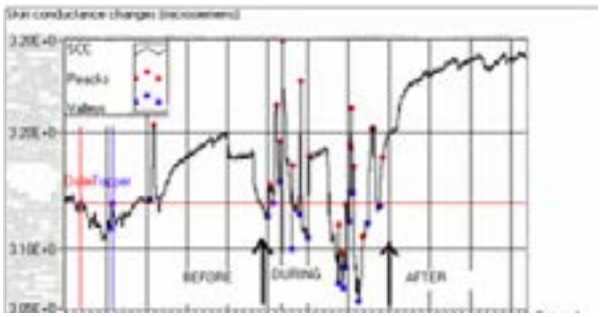
SCR/sec to approve torment was not utilized Search two, in regards to newborn children, included 20 outcomes where four of the papers additionally were in searh one .Of the staying 16, an expansion in the SCR/sec during difficult strategies was discovered (another three which were Russian), or that the SCR/sec was utilized for building up a torment score by testing variety between and inside patient. In one investigation the mean skin conductance level was utilized for torment appraisal which is less touchy to evaluate torment.

Figure 1: The changes in skin conductance is influenced from burst in the skin sympathetic nerves ac-



tivating the muscarinic receptors and then sweat is released from the sweat glands to the upper part of the skin before the sweat again is reabsorbed.

Figure 2: The skin conductance responses monitored



before, during, and after heel stick for blood sampling in infants from 25 weeks of gestational age. During painful procedures, the skin conductance responses/sec increases statistical significant.

The thoughtful nerve action in preterm babies seems, by all accounts, to be created to a last stage at around 25 weeks of gestational age. The Skin Conductance Algesimeter file, SCR/sec, has been utilized in a few examinations to screen torment. To look at the variety between and inside newborn children, the SCR/sec was concentrated in babies during rest, depicted as conduct state 1. The variety was somewhere in the range of 0.00 and 0.04, middle 0.00, when 15 babies were concentrated multiple times during 48 hours , likewise affirmed in the paper from Valkenburg. Curiously, when the SCR/sec was utilized as an agony pointer, 0.21 SCR/sec is utilized as a torment limit which is multiple times higher than the most extreme estimation of the SCR/sec of the newborn children who were snoozing (www.med-storm.com) (Table 2). When building up the Skin Conductance Algesimeter list for babies, Table 2, the SCR/sec was contrasted with the social agony scores, HR, and Newborn Individualized Developmental Care and Assessment Program (NIDCAP) medical attendants conduct rating score. The COMFORT sedation score and the newborn children's crying time previously, during and after agonizing strategies were likewise applied while building up the Skin Conductance Algesimeter list. Roughly 400 babies and youngsters took an interest in these examinations . These examinations show that the SCR/sec and observational agony scores increment during characterized excruciating methods in newborn children when tried. In one investigation concerning newborn children more youthful than 28 weeks of gestational age, it was just the SCR/sec that expanded during heel stick, not the NPASS observational torment score . A relationship between's the observational torment score, the Neonatal Infant Pain Score (NIPS), and the Skin Conductance Algesimeter record, SCR/sec, was found in newborn children during the procedure of heel stick for blood gas investigations (R=0.554, p=0.008) . A few investigations show that the SCR/sec isn't impacted by gestational and postnatal age during agonizing methods, and furthermore that it is conceivable to use from 25 weeks of gestational age (Figure 2). At the point when a cut off estimation of 0.571 SCR/sec was utilized, the affectability was 54.5% and the particularity was 79.4 when torment was estimated by the Neonatal Facial Coding System (NFCS) , the breaking down window for the SCR/sec was characterized to be just 5 sec.

The suggested cut off worth is 0.13 SCR/sec to find moderate and extreme torment, and the prescribed investigating window is characterized to be 15 sec (www.med-storm.com). In untimely newborn children, neuromuscular blockers ought to be utilized with alert, likely due to juvenile advancement of the muscarinic-nicotine receptor.

When examining torment in 20 babies and youngsters at the emergency unit of this examination have uncovered that quiet patients without upgrades have a SCR/sec of most extreme 0.03 [10], as per the Skin Conductance Algesimeter file, Table 2. In kids, a SCR/sec cut off estimation of 0.13 was found to recognize no or gentle agony versus moderate or extreme torment with an affectability of 90% and an explicitness of 64% (positive prescient worth 35%, negative prescient worth 97%) . Interestingely, when considering postoperative agony in kids, the SCR/sec was not affected by nervousness. Besides, absense of pain given to youngsters influenced by torment diminished the revealed torment and the SCR/sec. When contemplating babies and youngsters between the ages 0 to 11 years at the Intensive Care Unit, the SCR/sec and the directed Comfort sedation score expanded during attractions from trachea. The contrasts between the status preceding just as during attractions from trachea corresponded fundamentally between the two techniques, R=0.78, p<0.0005 . In the postoperative settings, when torment was concentrated by and large, no relationship between's the Skin Conductance Algesimeter record and the Numeric Rating Score was found [9]. The SCR/sec isn't affected by the youngsters' age.

Discussion: The thoughtful nerve action in preterm newborn children gives off an impression of being created to a last stage at around 25 weeks of gestational age. The Skin Conductance Algesimeter record, SCR/sec, has been utilized in a few examinations to screen torment. To analyze the variety between and inside babies, the SCR/sec was concentrated in newborn children during rest, depicted as conduct state 1. The variety was somewhere in the range of 0.00 and 0.04, middle 0.00, when 15 newborn children were concentrated multiple times during 48 hours , additionally affirmed in the paper from Valkenburg. Strikingly, when the SCR/sec was utilized as an agony pointer, 0.21 SCR/sec is utilized as a torment limit which is multiple times higher than the most extreme estimation of the SCR/sec of the newborn children who were snoozing (www.med-storm.com) (Table 2). When building up the Skin Conductance Algesimeter record for babies, Table 2, the SCR/sec was contrasted with the social agony scores, HR, and Newborn Individualized Developmental Care and Assessment Program (NIDCAP) attendants social rating score. The COMFORT sedation score and the newborn children's crying time previously, during and after agonizing methodology were additionally applied while building up the Skin Conductance Algesimeter file. Around 400 babies and kids took an interest in these investigations . These examinations show that the SCR/sec and observational torment scores increment during characterized excruciating systems in newborn children when tried. In one examination concerning newborn children more youthful than 28 weeks of gestational age, it was just the SCR/sec that expanded during heel stick, not the NPASS observational torment score . A relationship between's the observational torment score, the Neonatal Infant Pain Score (NIPS), and the Skin Conductance Algesimeter list, SCR/sec, was found in newborn children during the procedure of heel stick for blood gas examinations (R=0.554, p=0.008) . A few investigations show that the SCR/sec isn't affected by gestational and postnatal age during agonizing techniques, and furthermore that it is conceivable to use from 25 weeks of gestational age (Figure 2). At the point when a cut off estimation of 0.571 SCR/sec was utilized, the affectability was 54.5% and the explicitness was 79.4 when torment was estimated by the Neonatal Facial Coding System (NFCS) , the dissecting window for the SCR/sec was characterized to be just 5 sec. The suggested cut off worth is 0.13 SCR/sec to find moderate and extreme agony, and the prescribed investigating window is characterized to be 15 sec (www.med-storm.com). In untimely newborn children, neuromuscular blockers ought to be utilized

with alert, likely due to youthful advancement of the muscarinic-nicotine receptor.

Search one included twelve papers where five demonstrated outcomes from difficult methodology where the SCR/sec was utilized as torment appraisal. Search two included 20 aftereffects of which 19 indicated results from difficult or non-excruciating techniques where the SCR/sec was utilized for torment approval. All finds indicated that the SCR/sec expanded during characterized difficult techniques. Postoperatively, at serious consideration units, just as at neonatal units, the SCR/sec demonstrates a high affectability to screen torment, yet lower explicitness. A cut off estimation of 0.13 SCR/sec to find moderate and extreme torment, and a breaking down window of 15 sec are suggested.

Imperative fundaments for intense physiological torment evaluation scores in babies and youngsters who can't impart verbally are the assessment of pulse (HR), pulse changeability (HRV), respiratory rate, circulatory strain, oxygen immersion, close to infrared spectroscopy (NIRS), and palmar perspiring (SCR/sec).

Physiological factors like HR, HRV, pulse, NIRS, and fringe oxygen immersion might be misdirecting for approving agony in light of the fact that these elements fluctuate because of changes in the blood dissemination which happens during disease. The HR is impacted by the respiratory cadence [including apnoea and hypoxia, the utilization of mechanical ventilation, and the respiratory pain disorder), just as changes in the blood volume status. This likewise applies to drugs following up on the blood flow, for example, beta blockers and epinephrines, ecological temperature, just as passionate stressors for example fear bringing out or surprising circumstances , (Table 1). Strangely, the SCR/sec estimated palmary and plantary (reflecting barges in the skin thoughtful sensory system), isn't impacted by hemodynamic changes, ecological temperature, or respiratory cadence . Be that as it may, it is impacted by enthusiastic stressors for example dismay bringing out or unforeseen circumstances and the presentation of scholarly assignments. This is on the grounds that the SCR is actuated by acetylcholine following up on muscarinic receptors (Table 1 and Figure 1). It is imperative to utilize SCR/sec when checking torment. One ought to abstain from utilizing the skin conductance level (microsiemens), which is less exact to screen torment and which additionally conceivably relates with skin temperature . Both, the HR and the SCR/sec respond quickly, inside 1-2 sec, and are estimated progressively. The HR is affected by both thoughtful and parasympathetic nerve movement. Instead of the thoughtful sensory system, the parasympathetic sensory system develops and turns out to be progressively prevailing with expanding age. In one examination an expanded HR reaction was appeared to create with expanding gestational age in preterm babies . Besides, the HR during agonizing systems expanded more in preterm babies conceived < 28 weeks of gestational age at a postnatal age of about a month, when contrasted with babies at 32 weeks of gestational age. These outcomes demonstrate that the development of cardiovascular self-ruling control might be identified with gestational age, postnatal age, and the degree of neurologic development. The HR was concentrated in fifteen newborn children multiple times during 48 hours of rest (conduct state 1). It went from 110 to165 beats for each moment (bpm), with a mean of 137 bpm. It is in this manner a high variety of the HR between various newborn children and furthermore inside a similar baby when they are quiet or sleeping. Consequently it is hard to apply the HR as a standard score that is legitimate for all newborn children, in which a particular number of beats characterizes the torment level. These realities may scrutinize the utility of the HR as a torment evaluation apparatus when the point is to build up an agony file legitimate for all babies autonomous old enough. In the Intensive Care and Neonatal Units, when examining babies and kids between the ages 0 to 11 years, the pulse and agony scores expanded during pull from trachea and heel stick . Be that as it may, the distinction between the deliberate qualities before and during pull from trachea didn't relate es-

sentially between the two strategies .

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Financial Disclosure: The work has been performed as part of the University employment of Hanne Storm. Hanne Storm is also co-owner [shareholder] and CEO of Med-Storm Innovation, Gimle terrasse 4, Oslo, Norway, that has developed the Skin Conductance Algesimeter to monitor pain for commercial sale. For this study no specific funding was received.

Conflict of Interest: Hanne Storm is co-owner and CEO of Med- Storm Innovation, Gimle Terrasse 4, Oslo, Norway. This company has the right of the Skin Conductance Algesimeter to monitor pain for commercial sale.