

Objective Assessment of Acute Pain

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Abstract

Assessing acute pain in those unable to communicate is challenging yet essential. Objective assessment tools utilizing measures derived from autonomic changes alone or in combination appear to represent a potential solution to this difficult aspect of pain management.

Keywords: Pain; Assessment; Autonomic nervous system

Introduction

The evolutionary function of experiencing pain is to protect an organism against potential tissue damage from a noxious stimulus. However, pain is itself potentially harmful. In the short term it can be distressing and alter physiological parameters and without appropriate treatment can lead to long-term consequences such as chronic pain. Assessment is the foundation of effective pain management. It screens individuals for its presence, indicates severity helping to guide treatment, and finally evaluates the efficacy of such interventions.

Pain is “an unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such damage” [1]. It involves a complex interplay between nociceptive pathways and an individuals’ psychological and cognitive state, which interpret the noxious stimuli and relate this to one’s self and the environment. By definition this subjective experience is best evaluated by self-reporting assessment scales [2]. However, it is important to appreciate that the inability to communicate does not negate the experience of pain and its required management. In circumstances where self-assessment tools cannot be utilized, such as in individuals with cognitive or neurological impairment, alternative methods are required. Healthcare professionals are often unreliable in evaluating pain severity [3], hence the ideal objective assessment tool should remove observer error, be reliable in those unable to communicate and be uninfluenced by disease processes.

The field of developing reliable objective pain assessment tools is vast. It includes research areas that whilst interesting, are far removed from practical clinical implementation, such as real time neuroimaging and biomarkers [4]. More promising are those tools that focus on altered responses in the autonomic nervous system and composite algorithms that combine these with biopotential outputs such as electroencephalography (EEG).

The interaction between the autonomic nervous system and nociceptive pathways is intricate but incompletely understood. The two pathways overlap anatomically [5] and together alter hormonal and physiological responses. As such a traditional approach to evaluating pain, for example looking for changes in basic physiological

parameters such as blood pressure or heart rate, are unreliable and inaccurate [6]. These have been superseded by more complex measures including derived cardiovascular and respiratory parameters, which will be briefly described below.

The autonomic nervous system is an important determinant of cardiac function including the control of heart rate. Noxious stimuli are thought to decrease parasympathetic activity, and increase sympathetic and baroreceptor responses [7]. Heart rate variability (HRV) considers the time intervals between consecutive heartbeats. It uses frequency and time analysis to evaluate the relative contributions made by the parasympathetic and sympathetic nervous system [8]. Focusing on the predominantly parasympathetic component, HRV is thought to provide real time information regarding the autonomic response to noxious stimuli using standard ECG monitoring equipment. Whilst numerous factors can lead to inaccuracies including age, sex and medications [9-11], consistent responses have been observed in anesthetized patients to noxious stimuli and analgesia [12,13]. Results in non-anesthetized patients and healthy volunteers are less reliable, with HRV poor at determining pain intensity [8,14].

A number of algorithms were developed to improve HRV accuracy. The best evaluated is the analgesia nociception index (ANI[®], Mdloris Medical Systems, France). This combines the parasympathetic component of HRV with respiratory sinus arrhythmia, which influences heart rate [15]. It provides a continuous reading, creating a score from 0-100 where numbers over 50 are thought to reflect adequate analgesia. ANI scores respond reliably to surgical stimuli under anesthesia [16,17], however, there have been inconsistent results regarding a linear relationship with post-operative self-reported pain intensity scores [18-20]. Furthermore, the use of ANI to titrate intraoperative opioids has not demonstrated improved postoperative analgesia compared to normal practice. Specifically, the use of ANI has not been associated with a decrease in the occurrence of moderate to severe pain or rescue analgesia requirements [21].

The surgical pleth indexTM (previously called the surgical stress indexTM) is a measure derived from combining pulse photoplethysmographic waveform amplitude and normalized heart rate. It creates a linear scale score between 0-100, with high readings suggested to represent nociceptive stimulation [22]. Both of the

contributing measurements are thought to reflect the balance between sympathetic and parasympathetic tone, which is influenced by nociceptive stimulation. This non-invasive measurement has been shown to discriminate noxious stimuli under anesthesia [23]. In the post-operative setting however, it demonstrates only moderate sensitivity and specificity in identifying moderate to severe pain [24,25]. Furthermore it can be affected by factors including posture and volume status, that are suggested to account for variable inter-individual responses [26,27].

Sweating, a consequence of sympathetic activation of muscarinic receptors alters skin conduction and electrical resistance. Fluctuation in skin conduction is recorded as peaks. Nociceptive stimulation or pain is evaluated by either counting the number of peaks per second or combining this frequency with an area under the curve measurement [28]. It can identify different pain intensities in the post-operative setting [29,30] and detects noxious stimuli under general anesthesia [31]. However, the tool is prone to inaccuracies from the effect of the environment, the equipment used for its measurement and patient medication. Furthermore the response seen in healthy volunteers to noxious stimuli are highly individualized, which question the tools group level predictive properties [32]. Moreover, inconsistencies exist in its usefulness in pediatric and neonatal populations.

The infrared video-pupillometer utilizes the principle that in awake individuals' pupillary dilation is sympathetically mediated. Both the pupil diameter response to the noxious stimulus itself and light induced dilatation are thought to reflect sympathetic responses to pain. However, there are inconsistent results regarding the correlation between pupillary responses and post-operative self-reported pain scores [33-35]. Responses can also be influenced by drugs including opioids and vasoactive agents, along with environmental luminance and genuine conditions of the eye [36].

Science appreciates that often it is the interactions and relationships between variables that predict the responses of complex systems, rather than the absolute values of one parameter. This may be relevant to assessing pain, as it is highly unlikely such a complex experience is truly reflected by evaluating one autonomic variable or derived measure alone. In an attempt to address this, composite algorithms have been developed using statistical modeling of a number of autonomic and electroencephalography (EEG) variables. Combinations that best predict the presence and severity of pain are then used to create the algorithms. They either join a number of purely autonomic responses, exemplified for instance by the nociceptive level index [37,38] or combine autonomic responses with indicators of brain activity such as EEG or entropy measurements [39,40]. The latter are most relevant to evaluating nociceptive responses in anesthetized patients and responses correlate with the presence of noxious stimuli. The former have shown promise in post-operative patients and healthy volunteers to determine pain severity, and show increased accuracy than single parameters alone. The populations investigated however are small and homogenous, and as such the clinical application of these algorithms requires further validation.

Conclusion

Pain assessment is critical to ensure patients receive analgesia when in pain and to evaluate treatment effects. This is challenging yet especially important in those unable to self-report. Derived measurements, based on the autonomic response to nociceptive stimulation, show potential to evaluate pain objectively and composite

algorithms represent real promise. Unfortunately there is conflicting evidence. For example some methods are successful in guiding intra-operative analgesia, yet fail to translate to an improved post-operative pain experience. Furthermore tools successful in guiding intra-operative analgesia to blunt nociceptive responses, lack reliability in awake patients to determine pain intensity. Can these methods then be justified as tools to objectively measure pain?

This quandary perhaps reflects an approach to validating these tools that is too simplistic. Should an 'ideal' objective pain assessment tool have the ability to determine both the presence and intensity of pain in awake patients and also determine nociceptive stimulation in the anesthetized patient to guide analgesia? Striving to create a tool validated in both these areas could in part explain the evidence inconsistencies. These two clinical problems do not necessarily reflect the same entity and likely need to be evaluated in different ways. As such tools successful in addressing one area may still be clinically useful. This is illustrated by considering self-assessment tools. They have no place in evaluating pain in the anesthetized patient, yet are the gold standard for pain assessment in awake individuals. Therefore, to truly evidence these promising objective assessment tools investigators need to clearly consider what each measurement truly represents, how and what they are trying to validate and hence focus on what clinical question they are attempting to answer. Accordingly, research should now be directed to determine their specific place in the clinical setting.

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