Objective Pain Assessment: How Far Are We?

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Abstract

Pain treatment is one of the major challenges in clinical practice due to its subjectivity for communicative patients but also due to no pain measurement device for non-communicative patients. It is crucial to have an optimal pain treatment in order to avoid issues as over- or under-dosing; long period of recovery, etc. Therefore, an objective pain assessment is of key importance step in providing good pain management. This article will review the latest developed devices/methodologies/techniques for pain management.

Keywords: Pain Management; Objective Pain Assessment; Pain Model; Anesthesia

Introduction

Hitherto, there is no available method for objective pain assessment [1,2]. The standard techniques used in clinical practice are based on patient feedback such as Numerical Rating Scale (NRS) 0 no pain and 10 worst pain possible, Visual Analogue Scale (VAS). As not all patient are able to provide feedback to the nurse several tools have been developed for communication deficient patients: e.g. Behavioural Pain Scale (BPS); Critical Care Pain Observational Tool (CPOT); Pain Assessment and Intervention Notation (PAIN) Algorithm; Adult Non Verbal Pain Scale (NVPS). These are mostly in the form of questionnaires which presents disadvantages as large number of questions, the possibility that the patient does not correctly interpret the question, etc. which leads again to a subjective evaluation. Another class of patients where pain management is sub-optimal are patients under general anesthetic; patients in peri/post-operative care; patients in intensive care unit.

Hence, the benefits of an objective pain monitoring device would improve the quality of pain management in several clinical sectors such as: intensive care unit (patients on respirator are unable to communicate); premature and pediatrics (this would improve patient safety); surgery room; post-operative units (the under treatment of post-operative pain can delay patient recovery and discharge from hospital); etc.

In the last 20 years intensive research regarding pain assessment has been ongoing and several devices have been released on the market claiming the objective pain assessment. However, none of these devices are not employed in clinical settings as a standard procedure mainly due to lack of one device for all patient categories, not sufficient clinical trials have been performed to support the claims of objective pain measurement, no mathematically-physiologically (patient specific) based model to support its objectivity.

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In Section 2 a brief description of the existing commercial devices for pain management followed by Section 3 where the latest (mathematically based) technology for patient specific pain assessment is presented. In Section 4 the conclusions and future perspectives are presented.

**State of the art**

There are three medical devices available on the market for “objective” pain assessment. A short description of the available devices is given hereafter:

Med-Storm Pain Monitor is designed for three classes of patients: infants, children and adults, with more focus on infants and children. The principle of this device is based on measuring the skin conductance changes when a painful stimuli is applied. Several clinical trials have been performed to prove the reliability and specificity of the monitor. For example, in [3,4] the inter- and intra-patient variability has been investigated. The outcome was that the intra-patient variability is higher than the inter-patient variability. In another study a comparison between the Wong-Baker Faces Scale (gold standard in clinical practice) versus SC has been investigated [5]. In this study 150 children have been evaluated during routine care. The outcome of this study indicated that the self-reported pain score was significantly lower than the SC score. Although this device has its advantages it also has its limitations. More specifically, lack of previous comparison between SC and Wong-Baker faces scaled, difficulty to convert the SC data in a numerical scale that could be compared to Wong-Baker faces scale.

AlgiScan is a monitoring device based on pupillary re ex dilatation (PRD) and it is dedicated for patients under anesthesia. Several studies have shown that in response to an incision or tetanic electrical stimulation of the skin, PRD monitoring permits the detection of a increase in pupil size, even during general anaesthesia [6-8]. In [7] a pilot study has been conducted in order to test the hypothesis that whether or not the PRD can be used to assess noxious stimulation and analgesic effect of Alfentanil in children undergoing anaesthesia. The main outcome of this study was a proof of concept that the method can perceive the effects of peripheral nerve block. In [9] a comparison of the pupil size with heart rate, blood pressure and bispectral index has been performed.

The outcome of this study suggests that certain physiological reactions and pupil size changes may be potentially useful nociceptive indicators in intensive care unit settings. The limitations of this monitoring device are: is only valid for anesthetized patients, further research is required in order to determine the clinical parameters of physiologic response change and evaluate the effects of opioids and sedatives on these responses.

MEDASENSE monitoring device is based on a multi-parametric index for assessment of the presence and severity of pain. The finger probe continuously acquires physiological signals through four sensors. Several pain-related physiological parameters and derivatives are extracted and computed (Heart rate, Heart rate variability, Pulse wave amplitude, Skin conductance level, Number of skin conductance fluctuations, temperature and more). Advance machine learning algorithms identify the pain-related pattern and reflect the information on a scale where 0 represents no pain and 100 represents extreme pain the nociception level Index (NOL).

Studies have been published on the use and potential of this technology. In [10] a study on the development and validation of this method has been per-formed. In this paper the NOL for patients undergoing anaesthesia has been reported. In this paper the hypothesis of a new index for non-invasive assessment of patient level of nociception during anaesthesia, based on physiological parameters has been investigated. In [11] the ability of the NOL to detect noxious stimuli during anaesthesia has been investigated and the results indicate that during non-noxious event none of the parameters have changed. When incision took place an increase of the monitored parameters has been noticed. In [12] the use of NOL index and other measures of nociception to discriminate between noxious and non-noxious stimuli has been investigated. These studies suggests that the NOL index is a potential index for to distinguish non-noxious and graded noxious stimuli as well as the response to opioids. Although the research/studies performed indicate good results there is still room for improvement and more clinical studies are required to validate the device and to prove its accuracy and specificity.

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ANSPEC-PRO: The newest technology for pain assessment

The devices briefly introduced above have been evaluated mostly on sedated patients. Therefore, there is still much room for improvement. Although, clinically needed and theoretically promising, currently there is not enough evidence (i.e. clinical trials) to support the widespread use of any physiological sensors as ‘objective’ measures of pain. All devices available on the market are lacking a parametric mathematical model based on physiological processes. This is then the core innovative step the new technology developed by the Dynamical Systems and Control research team at Ghent University [13-15].

The newest technology developed by Ghent University is a non-invasive method for objective pain assessment by means of skin impedance measurement. The ANSPEC-PRO device can objectively detect pain and the first steps towards mathematical model of pain have been taken. The device is based on measurement of skin impedance. A preliminary study on 10 volunteers has been conducted at UGent and the results obtained indicate that the ANSPEC-PRO can detect when painful stimuli is applied. Several hypotheses have been tested in order to investigated the accuracy and specificity of the newest technology for objective pain measurement but there is still room for improvement. Currently, the research team investigates the development of a mathematical model to describe pain. In figure 1 the results obtained for a volunteer using the ANSPEC-PRO device are presented. These results indicates a proof of concept that the developed device can capture the dynamical changes when pain is present. An extensive analysis on the evaluated group of volunteers is not the goal of this article.

![Graphs showing skin impedance measurements](image)

**Figure 1:** Pain evaluation using the ANSPEC-PRO prototype device. NP denotes no pain situations, P denotes pain situations (i.e. a pain stimulus has been applied).

Future perspectives

Based on the promising preliminary results obtained with the ANSPEC-PRO technology the following aspects will be investigated: investigated the inter- and intra-patient variability; accuracy, specificity and repeatability of the device; monitor patients in the intensive care unit; investigate whether or not the mathematical model can capture the dynamics within each patient.

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Once all the challenges presented above are addressed a fully automated drug delivery system can be developed. The benefits of such a delivery system incorporates both social and economical aspects. From the social perspective patient’s well-being is improved by means of a better pain treatment; avoiding situations such as over-/under-dosing. From the economical perspective a reduction of costs will be achieved by a faster discharge of the patient due to a better pain treatment; reduction of analgesic costs.

Bibliography


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