ASSESSMENT OF THE LINEAR CORRELATION BETWEEN VITAL SIGNS AND PERCEPTUAL PAIN IN THE CONTEXT OF BURN INDIVIDUALS

M. J. F. Zaruz*, F. M. Lima*, S. Walter**, E. F. Daibert***, A. A. Pereira*, A. O. Andrade*

* Faculty of Electrical Engineering, Federal University of Uberlandia, Uberlandia, Brazil
** Department of Psychosomatic Medicine and Psychotherapy, University Ulm, Ulm, Germany
*** Burn Unity, Clinical Hospital of the Federal University of Uberlandia, Uberlandia, Brazil
email: fisio.mz@hotmail.com

Abstract: Burns are one of the worst injuries to humans, due to intense pain related to initial injury itself, wound care and other physical treatments which can least from days to months. It can lead even to death or provoke physical impairments and psychological suffering. A number of studies suggest the existence of correlations between biological signals and the presence of pain and its severity. Therefore, we aim to assess the linear correlation between vital signs and perceptual pain in the context of burn individuals. Vital signs, oximetry and blood pressure were collected together with the Verbal Numeric Scale (VNS) pain measure for four different conditions (wound care [P1], physiotherapy [P2], and at rest, 2 [R1] and 5 [R2] hours after opiate medication administration) from one inpatient at a the Burn Unit of the Clinical Hospital of the Federal University of Uberlandia, Uberlandia, Brazil. Linear regression and correlation coefficients were evaluated to compare linear trend models of each variable among all four conditions. Moderate correlations were found for Pulse and HR in conditions R1 (negative correlation) and R2 (positive correlation), for MAP and DBP in condition R1 (positive correlation) and for O_2 in condition R2 (negative correlation). Larger correlation and slope were found for Pulse and HR at rest in the absence of medication effects. We conclude that painful procedures and opiate medication may influence the linear trend of biological parameters in the context of burn patients, which should be further analyzed.

Keywords: Burn, Oximetry, Pain, Pain Measurement, Vital Signs.

Introduction

Burns are one of the worst injuries to humans, due to intense pain during the accident itself, and during wound care, which can last from days to months. It can lead to death or physical impairments and psychological suffering for the rest of one's life [1, 2].

In order to evaluate patient's pain, there are many tools such as subjective pain scales and questionnaires, though they depend on the patient's self report about the location, type and intensity of pain [3].

Recent studies suggest the existence of correlations between biological signal measures and the presence of pain [4]. In this sense, it would be also possible to quantify the amount of pain one experience, even when one is incapable to express himself.

Therefore, in the light of the most recent findings on pain measurement we propose the evaluation of the linear correlation between vital signs and perceptual pain.

Materials and methods

Study design – This paper is a case study of a severe burn inpatient at the Burn Unity of the Clinical Hospital of the Federal University of Uberlandia (Ethics Committee Protocol - 750.493/2014). To track changes in vital parameters related to pain sensation, we monitored the patient continuously, during four distinct conditions: a) during wound care (P1); b) during physiotherapy (P2); c) at rest, 2.5 hours after pain relief medication intake (R1), and; d) at rest, 5 hours after pain relief medication intake (R2). As pain killer, the subject took Morphine Sulfate, and the rest intervals were set to collect data in the presence and in the absence of analgesic effect, which lasts between 4 to 5 hours when administrated intravenously. The patient was assessed in different days for 3 weeks.

Participant – a 33 year old male farmhand who sustained an electrical burn injury for one week at the time of the commencement of data collection participated of this study.

Variables – The following parameters were collected at 0.017Hz (1 sample per minute): a) Pulse; b) Oximetry (SpO_2); c) Body Temperature (BT); d) Heart Rate (HR), and; e) Respiration Rate (RR). Blood pressure parameters were collected at 0.008Hz (1 sample every 2 minutes): a) Systolic Blood Pressure (SBP); b) Mean Arterial Pressure (MAP), and; c) Diastolic blood Pressure (DBP). Clinical staff also assessed and annotated the Subjective Pain Sensation (PS) every two minutes by means of Verbal Numeric Scale (VNS).

Data Acquisition – Commercial version of a Multi Parameter Monitor (DX 2020 – DIXTAL BIOMÉDICA, Brazil) was used to collect and to store data. The data were later transferred to the computer for offline processing.

Blood pressure sphygmomanometer was positioned at the patient's arm opposite to venous accesses to prevent any circulatory complications. Temperature

sensor was placed in the armpit of the same arm. Pulse and oximetry were measured by positioning the sensor on the distal phalanges of the 2nd or 3rd fingers of the opposite hand to prevent inaccurate measures. Heart Rate and Respiration Rate are automatically inferred from electrocardiography by the Multi Parameter Monitor.

Data Analysis – Data analysis was carried out in Matlab® (MATHWORKS, United States of America) to compute the linear regression and the correlation coefficients for each parameter as a function of subjective pain sensation for each of the four conditions.

Results

A total of 20.4 hours of data were collected over three weeks for each experimental protocol (272 minutes from P1, 505 minutes from P2, 285 from R1 and 162 from P2).

A linear model was fitted to the data, in order to describe the correlation between perceptual pain and the investigated variables. Table 1 summarizes the linear trend found for each protocol. We show only the sign of the angular coefficient for each case.

In Figure 1 we present the correlation coefficients between the evaluated parameters and pain sensation for each of the four conditions (P1, P2, R1, and R2). Moderate correlation was found for Pulse and HR in conditions R1 (positive correlation) and R2 (negative correlation), for MAP and DBP in condition R1 (positive correlation) and for O_2 in condition R2 (negative correlation).

Table 1 – Linear Trend evaluation of each variable as a function of pain sensation values for each condition.

Variable	P1	P2	R1	R2
SBP	+	+	+	-
MAP	+	+	+	-
DBP	+	+	+	-
Pulse	-	+	-	+
O_2	-	+	+	-
HR	-	+	-	+
BT	-	+	-	+
RR	-	+	-	+

Note: (+) Increasing; (-) Decreasing.

Discussion

Pain evaluation and management is still an ongoing issue of concern for patients with burns [3], especially due to unpleasant procedures necessary to appropriate healing of patients, such as wound care and physiotherapy.

In this study we investigated the linear trends of a number of biomedical variables with regard to perceptual pain.

To the best of our knowledge, this is one of the first studies in the current literature, which monitors burn patients continuously.

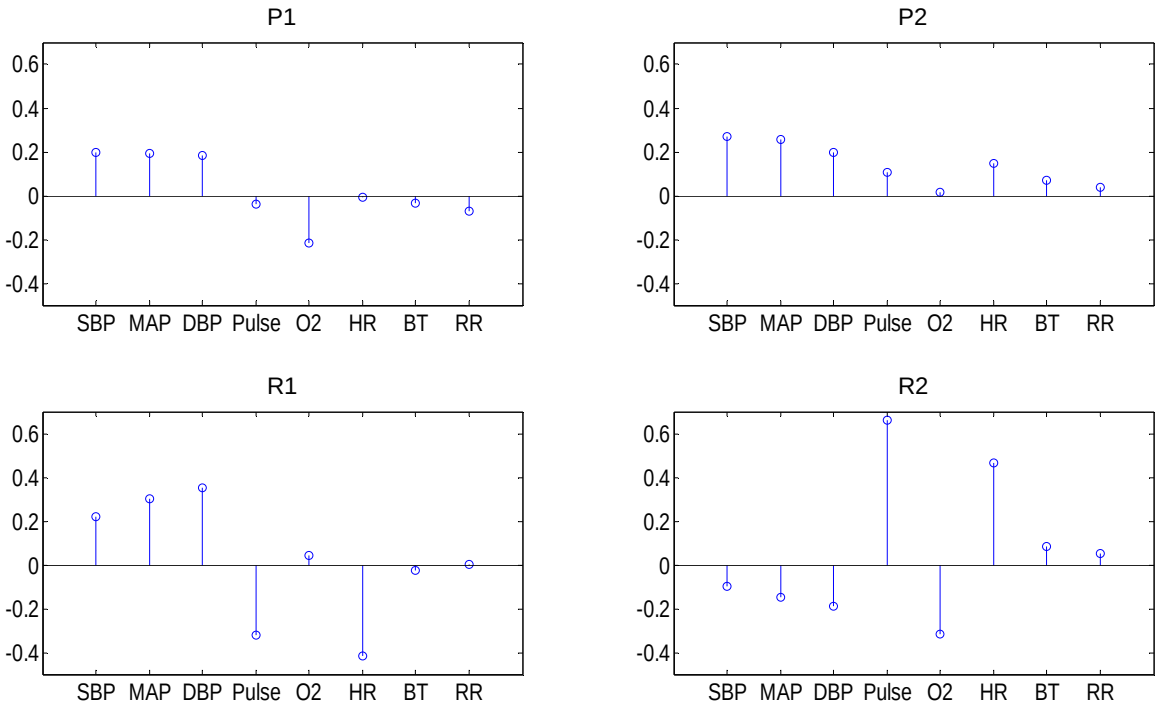

Figure 1: Correlation coefficient estimated for each experimental protocol (P1, P2, R1 and R2). The correlation was estimated between the pain intensity and the studied variables (SBP, MAP, DBP, Pulse, O2, HR, BT and RR).

In the context of severe burn patients, metabolic imbalances are common and patient's metabolism can increase up to 200% in the first hours following the accident. In addition, high distress levels also imply changes in the autonomic nervous system and in vital signs, as well, due to an increase in dopamine levels [5, 6].

Pain and distress are known to cause sympathetic activity increases, which are related to increased blood pressure, heart rate and respiration rate due to peripheral vasoconstriction and increased blood influx and increased contractility in the heart [6]. Thus, we hypothesized that vital signs could be positively correlated to pain intensity levels.

In contrast, Morphine Sulfate acts at the Central Nervous System and smooth muscles. Its effects include analgesia, somnolence, euphoria, and dosage-dependent body temperature reduction, and respiratory depression. Side effects like respiratory depression, sedation, blood pressure reduction and heart rate increase may also occur [7].

These facts might partially help to explain our findings, as none of the evaluated parameters showed the same responses for all four conditions.

During condition P1, patient were experiencing very painful procedures (wound care) which are meant to increase vital signs values, but he was also under peak medication effect, which might cover exacerbated sympathetic activity responses. In our experiments, the more pain the patient felt, the larger the pressure measurements, and smaller the other parameters. However, all correlations were found to be weak.

During condition P2, the participant was still experiencing painful procedure (physiotherapy), but with no medication effect on pain control. Here all evaluated parameters increased with increased pain, in accordance with increased sympathetic activity due to pain and physical activity. However, all evaluated parameters showed weak correlations with increased pain.

During condition R1 there was no painful procedure happening, but the medication was still acting in pain control (2.5 hours after medication administration). Here, SBP, MAP, DBP and oximetry increased for increased pain, whereas Pulse, HR, BT and RR decreased. Moderate correlation was found only for MAP, DBP, Pulse and HR. Other evaluated parameters showed weak correlations.

During condition R2, there were no Morphine Sulfate effects on pain control, but the patient was experiencing background pain (5 hours after medication administration).

Although it was expected to find increased values for both blood pressure measurements and heart rate measurements with increased pain due to sympathetic activity, only Pulse and HR showed moderate positive correlation with increased pain, whereas SBP, MAP and DBP showed weak negative correlation with increased pain values. In addition, oximetry values also showed moderate negative correlation with increased pain values. Weak positive correlation was found for BT and RR.

To sum, this research found no strong correlation between biomedical signals and pain intensity, which suggests the linear trends of the evaluated parameters might not be good tools to track and monitor pain intensity in burn patients. However, the study assessed data from only one individual, and differences might be found in a larger sample, especially with respect to Heart Rate and Pulse which presented higher correlation values.

Conclusion

Based on a single case study, the authors conclude that linear trend models of biomedical signals were not consistent tools to monitor increasing pain in the context of burns patients. Nevertheless, a larger sample must be assessed to confirm this finding. Despite none of the parameters had shown similar tendencies in different contexts, Pulse and HR were those with larger slopes and correlation coefficients values, and thus, they still might be a good source of information for the development of pain monitoring systems in the very next future. However, the influence of opiate and other pain killer medication effects, as well as the influence of nociceptive treatments like wound care and physiotherapy should be further analyzed in the context of burn patients.

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