ON THE USE OF BIOMEDICAL PARAMETERS FOR THE OBJECTIVE PAIN ASSESSMENT IN SEVERE BURN PATIENTS: A CASE STUDY

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Abstract: Pain is a major problem in severe burn patients and it causes great physical and psychological suffering together with the burn injury. Biological parameters such as vital signs have been suggested as pain indicators to monitor pain, but just a few studies have attempted to study their variability as a possible source of information. Therefore, we aimed to evaluate different biomedical parameters for pain recognition in severe burn patients based on a case study. Vital signs, oximetry and blood pressure were collected together with Verbal Numeric Scale for four distinct conditions from a burn inpatient. Variables were arranged in ascending order regarding Pain Sensation values. Significant differences were found for the four different conditions. Heart Rate was found to be significantly different between baseline and increased pain values in three of them. Pulse and Respiration Rate variances showed consistent patterns in all four situations. All in all, we conclude that variance values of respiration rate and Pulse might be probably the main parameters among the analyzed biological parameters that might be used to identify and monitor increasing pain sensation in burn patients. Despite finding significant differences in other parameters, they may fluctuate during different conditions and should be further analyzed in a larger sample to bring more insights to the field.
Keywords: Burns, Oximetry, Pain, Pain Measurement, Vital Signs.

Introduction

Pain is a major problem for severe burn patients. They usually have to deal with the initial pain related to the accident itself, and then, this pain continues for days or even weeks. Depending on the depth, the extension and the type of the initial injury, many problems, surgical procedures and amputations may follow. In addition, wound care procedures and rehabilitation programs are needed, and they also cause much more pain than the background pain from the wound itself. All this process causes great physical and psychological suffering [1-3].

To evaluate patient's pain, the most common used tools are subjective pain scales and questionnaires, which depend on the patient's self report about location, type and intensity. On the other hand, recent studies have been suggesting a correlation between biological signal measures and pain sensation intensity. In this sense, it is not only possible to monitor the presence or absence of pain, but also to quantify the amount of pain one experiences, even when one is incapable to express himself.

Therefore, in the light of the most recent findings about pain measurement and severe burns patient's pain, we aimed to evaluate different biomedical parameters for pain recognition in severe burn patients based on a case study.

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 Sulphate, 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 for data acquisition and storage. 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 and Statistics – Data analysis was carried out in Matlab® (MATHWORKS, United States of America) and in Statistics 8.0® (STATSOFT, United States of America). Acquired data were sorted out in ascending order regarding PS values. Shapiro-Wilks analysis was use for normality evaluation, and repeated measures Anova with Scheffé *post-hoc* test to compare differences between groups, since all variables showed to have normal distribution. Descriptive statistics was also used to infer possible variance patterns among different groups.

Results

In three weeks we recorded approximately 20.4 hours of data (272 minutes from P1, 505 minutes from P2, 285 from R1 and 162 from P2). The collected data was separated to 8 subgroups presenting baseline and increased pain values for each variable under 4 different conditions. Mean and variance values are shown in Table 1. Figure 1 shows a typical example of the Pulse variability as a function of the pain sensation. For each condition (P1, P2, R1and R2), data were separated into baseline values (up to the first increment step of pain sensation) and increased pain values (starting from the first increment step of pain sensation).

Significant differences in SBP, MAP DBP, Pulse, SpO_2 and HR values were found between baseline and increased pain subgroups at both rest situations (R1 and R2). Significant difference in HR and BT values were found between baseline and increased pain subgroups during physiotherapy (P2). Significant difference in BT and RR values were found between baseline and increased pain subgroups during wound care (P1). Significant difference in RR values was also found at R1 (Table 2).

Considering data variance, for almost all parameters and situations, variance values were greater in increased pain than baseline subgroups, except for P1, in which 5 out of 8 parameters showed lower variance values in increased pain than baseline subgroups. In addition, Pulse and RR were the only variables that showed a similar pattern regarding increased pain in all 4 situations. Their variance values were always larger in increased pain subgroup than in baseline one (Table 1).

Discussion

As a terrifying sensation, patients can lie about their pain intensity to receive more and more medication as a fear of feeling pain, especially before wound care, bath and physiotherapy. Despite being necessary treatments for patient's healing, health care professionals must take patients' pain sensation to account during all these unpleasant procedures. In these cases and in cases of unconscious inpatients, a pain monitoring system would help to control drug delivery and to point out patients that should be closely followed by doctors and psychologists.

In this work we identified biological parameters that might be used to identify pain in burn patients.

Table 1 - Mean and Variance values for each of the six variables separated by baseline pain and increased pain values for the four distinct conditions.

Variable	Groups															
	P1				P2				R1				R2			
	Baseline (1)		Increased Pain (2)		Baseline (3)		Increased Pain (4)		Baseline (5)		Increased Pain (6)		Baseline (7)		Increased Pain (8)	
	Mean	Var	Mean	Var	Mean	Var	Mean	Var	Mean	Var	Mean	Var	Mean	Var	Mean	Var
SBP (mmHg)	125.6	4.9	133.2	106.9	129.4	241.9	131.7	155.6	119.6	76.2	134.6	130.1	139.4	41.5	131.2	64.6
MAP (mmHg)	100.6	1.6	104.2	78.8	100.9	192.1	99.1	35.6	90.4	57.0	103.4	60.2	106.4	8.4	100.5	37.2
DBP (mmHg)	88.1	6.6	89.7	82.5	82.9	39.4	83.0	30.9	75.6	58.0	87.9	41.9	90.0	5.6	85.0	35.7
Pulse (bpm*)	101.7	8.7	104.5	90.3	121.5	2.3	126.5	108.8	109.6	8.7	103.7	25.9	104.3	21.2	114.0	96.6
SpO2 (%)	94.4	0.2	94.1	5.6	94.1	0.9	94.1	4.9	93.6	2.7	94.9	3.2	95.3	4.0	93.5	2.3
HR (bpm*)	102.5	4.4	105.0	76.5	111.0	1342.8	126.8	120.6	110.6	7.6	104.2	23.1	104.4	20.0	111.9	256.9
BT (°C)	36.6	0.0	34.7	5.4	33.1	20.8	36.7	0.4	36.6	0.1	35.8	1.8	36.2	0.0	35.9	1.7
RR (bpm**)	6.6	32.6	14.5	46.8	15.3	12.2	16.7	32.4	20.3	29.2	19.0	31.0	16.0	32.8	14.7	34.2

P1 - Wound care; P2 - Physiotherapy; R1 - At rest, 2.5 h after medication intake; R2 - At rest, 5 h after medication intake; Var - Variance; SBP - Systolic Blood Pressure; MAP - Mean Arterial Pressure; DBP - Diastolic Blood Pressure; SpO2 - Peripheral capillary oxygen saturation; HR - Heart Rate; BT - Body Temperature, and; RR - Respiration Rate. * Beats per minute. ** Breaths per minute. Significant values are indicated in red.

Table 2 - *Post-hoc* Scheffé *p* values for the Repeated Measures Anova statistical analysis comparing baseline vs. increased pain values for each condition.

Variable	P1 (1) vs. (2)	P2 (3) vs. (4)	R1 (5) vs. (6)	R2 (7) vs. (8)
SBP	0.393850	0.998524	0.000000	0.004127
MAP	0.890803	0.998743	0.000000	0.007815
DBP	0.998924	1.000000	0.000000	0.040150
Pulse	0.985045	0.761360	0.003674	0.000001
SpO_2	0.999975	1.000000	0.004823	0.000117
HR	0.998295	0.000348	0.021929	0.027989
BT	0.025224	0.000000	0.312283	0.997865
RR	0.002771	0.998398	0.955730	0.000101

P1 - Wound care; P2 - Physiotherapy; R1 - At rest, 2.5 hours after medication intake; R2 - At rest, 5 hours after medication intake; SBP - Systolic Blood Pressure; MAP - Mean Arterial Pressure; DBP - Diastolic Blood Pressure; SpO2 - Peripheral capillary oxygen saturation; HR - Heart Rate; BT - Body Temperature, and; RR - Respiration Rate. (1), (3), (5) and (7) – Baseline values. (2), (4), (6) and (8) – Increased pain values. Significant values are indicated in red.

Pain is still an ongoing issue of concern in adult burn patients [3, 4]. In 2012, Mahar and colleagues [3] stated that Numeric Rating Scales and Analogue Visual Scales were the most used tools to assess burn patients' pain in Randomized Controlled Trials. In their review, only two [5, 6], out of 22 studies, were reported to monitor vital signs. One [5] of these two studies were also reported to monitor oximetry. Although they did not aim to quantify pain by means of biomedical measurements, they gave us some insights about the topic. In the first one [6], vital signs were used to monitor changes due to music relaxation interventions on pain and anxiety levels, but they found no significant difference. In the second one [5], there were reductions in HR but no changes in MAP or SpO_2 that were associated with a specific group that needed less pain killers intake after surgical intervention.

In Intensive Care Units, Arbour and Gélidas [7] found many biological parameters (MAP, HR, RR and end-tidal CO_2) to increase during nociceptive procedures compared to baseline values, while SpO_2 decreased, but they could not support the use of this parameters to be valid indicators for pain assessment, because they showed many fluctuations during the recovery period after nociceptive procedures under different conditions.

Arbour and colleagues [8] also found increase in fluctuations of biological parameters such as SBP, DBP, MAP, HR, RR, SpO_2 and end-tidal CO_2 in both nocipetive (turning) and non-nociceptive (noninvasive blood pressure measurement) procedures in Traumatic Brain Injury inpatients, but only in nociceptive procedures for RR. Nevertheless, they also state that RR should be used only as a probable pain indicator and should be further evaluated.

Kapoustina and colleagues [9] also examined the validity of behaviors and fluctuations in vital signs as pain intensity indicators after elective brain surgery. Despite fluctuations in many biological measures, only RR differed significantly between non-nociceptive and nociceptive procedures, but only behavioral responses positively correlated to self-reported pain intensity.

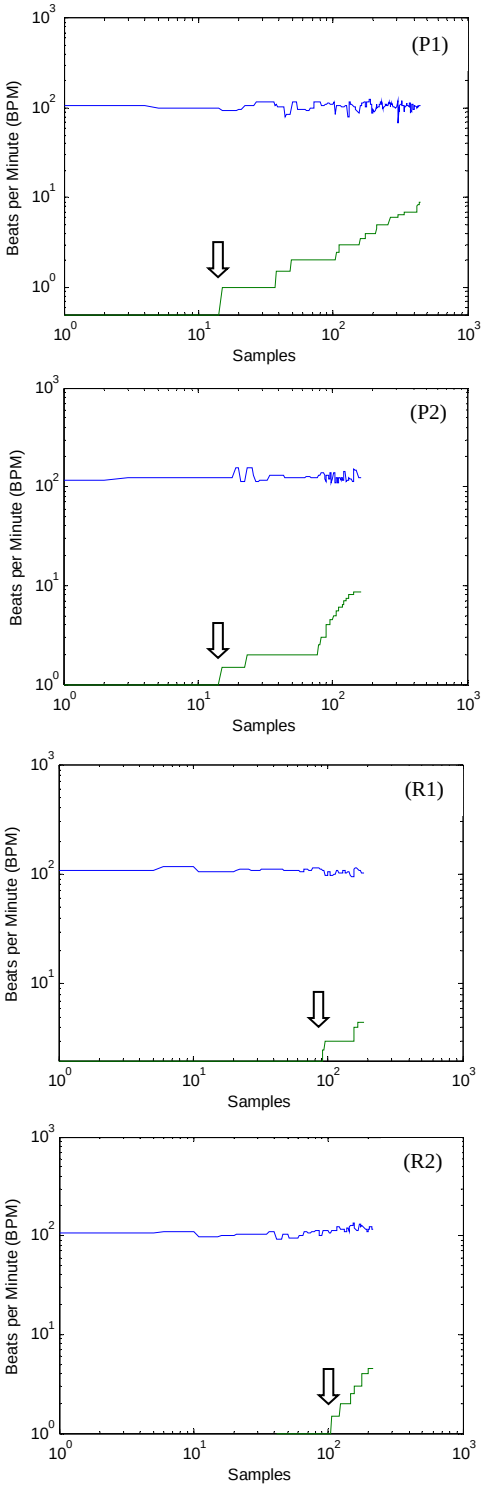

Figure 1: Example of Pulse (blue) variability as a function of increasing pain sensation (green) in logarithmic scale for the four distinct conditions (P1, P2, R1 and R2), where arrows indicate the division between baseline (left) and increased pain values (right).

Sharhaki and colleagues [10] used visual analogue scale and vital signs to study the effect of anti-inflammatory drugs in short time post-operative pain control. They found lower values of MAP and HR in case group than in control group, related to less severe pain sensation.

Many other studies advise that vital signs are inconsistent among different situations, and that they solely are not valid pain indicators, as they might be influenced by many phenomena other than pain [11, 12].

Considering the procedures we used in this study, wound care and physiotherapy procedures (P1 and P2) are thought to be nociceptive procedures, as they stimulate pain when wounds are washed or stretched, or when debridement is needed. The other two situations were meant to evaluate situations in which there is no nociceptive procedure, but there is still an increasing background pain in the presence of analgesic effect (R1) and in the absence of it (R2).

Significant differences were found in HR for P2, R1 and R2, but there were no consistence among them. Despite having the same meaningful information, Pulse did only differ significantly in R1 and R2. This result shows us that differences in the acquisition methods or equipment may influence results. While HR was inferred from electrocardiography, Pulse is inferred from plethysmography.

Many conflicting information were found regarding other biomedical parameters. All pressure values increased significantly with increased pain sensation while under medication effects, but decreased significantly in the absence of medication effects.

Pulse and HR values showed the opposite pattern, with values decreasing significantly with increased pain sensation while under medication effects, but increased significantly in the absence of medication effects. HR also increased with increased pain sensation during physiotherapy, but not during wound care. Respiration rate increased during wound care, but decreased at rest in the absence of medication effect. Body temperature showed controversial results during nociceptive procedures. It increased during physiotherapy, but decreased during wound care.

These findings can be either a single pattern from a unique burn patient or the confirmation that biomedical parameters are affected by many factors and could not be considered pain indicators themselves alone.

Our plan is to collect larger data set from different volunteers in the very next future to obtain more reliable information about burn patients and to compute statistical analysis of variance values from RR and Pulse variables, especially.

Conclusion

We conclude that variance values of Respiration Rate and Pulse may be probably the main variables among the analyzed biological parameters that might be used to identify and monitor increasing pain sensation of burn patients. Despite finding significant differences in other parameters, they may fluctuate during different conditions and should be further analyzed in a larger sample group to bring more insights into the topic.

Acknowledgements

The authors would like to thank the Clinical Hospital staff and the inpatients of the Burn Unity for the attention and availability, and CAPES, CNPq and FAPEMIG for the financial support.

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