Hindawi
Pain Research and Management
Volume 2020, Article ID 6312581, 4 pages
https://doi.org/10.1155/2020/6312581

Research Article

Pain Vision System for Evaluating Chronic Pain: A Comparison with VAS Scoring

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Received 2 September 2019; Revised 3 February 2020; Accepted 28 February 2020; Published 9 April 2020

Academic Editor: Anna Maria Aloisi

Objective. To study the value of pain vision system in quantitative evaluation of chronic pain from the perspective of neuroelectrophysiology, as compared with VAS (visual analog scale). *Methods*. Seventy-one patients with chronic pain were randomly selected to receive pain treatments from August 1, 2018, to September 30, 2018, in the Pain Department of Li Zhuang Tongji Hospital. Among all patients, 26 had cervical spondylosis and 45 had lumbar disc herniation. Pain vision and visual analog scoring (VAS) were used to evaluate the degree of pain before and after treatment. The correlation between the pain vision system's pain ratio (pain ratio) and the VAS score was analyzed. *Results*. Pain ratio and VAS scores were linearly correlated before and after treatment in patients with chronic pain (Pearson coefficient was 0.730 before treatment and 0.449 after treatment; $P < 0.001$). *Conclusions*. The pain vision system can evaluate chronic pain well and quantify it in the form of pain degree, which is helpful for objective quantitative analysis of chronic pain. This trial is registered with ChiCTR1900026331.

1. Introduction

Pain is one of the most common clinical symptoms. Due to its subjective characteristic, it is difficult for medical staff to judge its degree through their clinical experience. Nowadays, visual analog scale [1], numeric rating scale [2], faces pain scale, verbal descriptor scale, and five-finger method [3] are mainly used to indirectly measure the degrees of pain.

The World Health Organization has also defined pain as the "fifth vital sign" after body temperature, pulse, breath, and blood pressure. Although there are many studies on the physiology and pathology of pain, there are only few reports on the objective measurement of pain intensity. The pain vision perception and pain sensation quantitative analysis instrument was developed by Nipro Company in Japan for quantitative analysis of pain intensity of disease. The instrument detects pain with an electrode that is placed on the sensitive part of the subject's body surface and sends out a slight electro-stimulus. The intensity of the current is known here as the current perception threshold (CPT), pain equivalent current (PEC) represents the pain the subject feels, and the ratio of PEC to CPT is known as the pain ratio. Pain ratios of all types of causes are measured with same standards. Various pain ratios were consistent with the subjective pain scale. It has been reported in China that this instrument can be used for the quantitative evaluation of cancer pain and pain after laparoscopic surgery [4, 5], but not for the evaluation of labor pain [6]. Few scholars have studied whether it can be used in the field of chronic pain.

Chronic pain usually refers to pain that lasts for more than three months or intermittent pain. Many doctors only consider pain that lasts for more than six months as chronic pain because of the complexity of its etiology, clinical manifestations, and difficulty for accurate evaluation. Therefore, no pain measurement of chronic pain has been reported in China so far. Foreign clinical studies suggest that pain vision system can cooperate with other methods for pain assessment [7]. The purpose of this study is to evaluate pain ratio in patients with chronic pain by the pain vision system and compare it with the subjective pain scale (VAS).

The consistency between pain ratio and subjective pain scale (VAS) was analyzed in order to understand whether the PV system can be used to quantify chronic pain.

2. Information and Methods

2.1. Research Object. Seventy-one chronic pain patients aged 25–75 years were randomly selected from the Pain Department of Tongji Hospital, Li zhuang, Third People's Hospital of Yibin from August 1, 2018, to September 30, 2018. Among all, 26 patients had cervical spondylosis and 45 had lumbar disc herniation. There were 34 males and 37 females. All the subjects were required to be clear-minded/self-aware and sensitive, with a full understanding of the pain vision system and VAS operation process. The patients are also expected to be able to accept specific instructions of the operation.

2.2. Research Methods. The pain vision system has advantage of low cost, only need the cost of the instrument. It will not cause other discomfort on the basis of the patient's own disease. The maximum intensity of the pain generated by the instrument is not higher than the patient's own intensity, and the instrument will not cause damage to the human body. The PVS is more intuitive and facilitates quantitative expression.

2.2.1. VAS Method. Using a swimming ruler with a length of 100 counting units, the "0" and "100" scales at both ends are used to represent "painless" and "unbearable intense pain." The patient marks a point on the scale that represents his or her current perception of the degree of the pain. The doctor therefore can evaluate the VAS value according to the patient's own opinion. All patients in this study were tested by the pain vision system after completing the VAS assessment.

2.2.2. Pain Vision System Method. The parameters are set as default parameters: the measuring time is 100 seconds (s), the limiting current is 256 microampere, and the limiting voltage is 100 volts (V). Subjects were asked to lie on their back or sit back and relax with their upper limbs naturally placed on the sides of their bodies, palms up. Apply the disposable electrode to the middle of the ulnar flexure 2 cm above the horizontal stripes of the wrist on the inside of the left forearm, press the right hand lightly on the electrode piece to make the electrode piece fully contact with the skin, and operate the handle with the left hand. Turn on the pain vision system and enter the patient name, gender, age, and other information to start the measurement. When the patient feels slight stimulation, press the handle and repeat the process three times. The average value is CPT. The pain vision system was started again in 3–5 minutes after the body rest. When the patient felt the pain generated by the electric current stimulation and the pain itself, he should press the handle at that time; repeat three times and take the average value as PEC. The data were input into Excel and converted to pain ratio to represent the pain intensity of patients. The conversion formula was as follows: pain ratio = PEC/CPT.

2.3. Statistical Processing. SPSS20.0 software was used for statistical analysis. The measurements were expressed by mean (±standard deviation). The Pearson correlation test was used to test the measurements of the pain vision system and VAS method. The correlation coefficients are expressed in P. When $P < 0.05$, they are correlated.

3. Results

All patients successfully completed this study. The pain vision system and VAS method (see Table 1) showed that pain was significantly reduced after the treatment. This study mainly focused on the correlation between the two and did not make much analysis of the efficacy.

The pain ratio and VAS score of chronic pain patients were linearly correlated before treatment (Pearson coefficient was 0.730 and $P < 0.001$, respectively). The relationship between pain ratio and VAS score was analyzed by the linear regression method with one variable. The relationship between pain ratio and VAS score was as follows: pain ratio = 0.782 ∗ VAS=2.252, as shown in Figure 1. The pain ratio and VAS scores were also linearly correlated after treatment (Pearson coefficient was 0.449; $P < 0.001$). The unary linear regression method was used to analyze the relationship between pain ratio and VAS pain score. The relationship between the two unary linear equations was as follows: pain ratio = 0.245 ∗ VAS = 1.213, as shown in Figure 2.

4. Discussion

It is difficult for the doctor to judge the intensity of pain through their own clinical experience. The VAS method, because of its high sensitivity and high credibility and validity, has become the most commonly used effective and reliable method for assessing pain. Therefore, this study is based on the VAS method, uses the PVS to test the pain degree of patients with chronic pain, and compares it with the VAS method to study the correlation between the two and explore whether the PVS can be used for chronic pain assessment.

Pain is an unpleasant subjective feeling and emotional experience induced by tissue injury or potential tissue injury. It is usually accompanied by physiological and psychological changes. When the body is subjected to noxious stimulation, it often causes pain, accompanied by certain defensive responses, which are of protective significance to the body. But long-term severe pain will also be accompanied by unpleasant emotional reactions and can affect appetite, sleep, mental state, etc.. The mechanism of pain has not been fully understood so far. It is generally believed that nociceptors are stimulated by various physical or chemical injuries and then transmitted to the brain via afferent nerves to cause pain. The nerve fibers conducting pain are generally considered to be relatively thin, including A-delta fibers and C fibers. It is believed that A-delta fibers transmit prickling

Table 1: Pain vision system measured pain ratio and VAS method before and after treatment.

	Before the treatment	After the treatment
Pain vision	3.74 ± 1.02	2.02 ± 0.83
VS	7.68 ± 0.95	3.30 ± 1.52

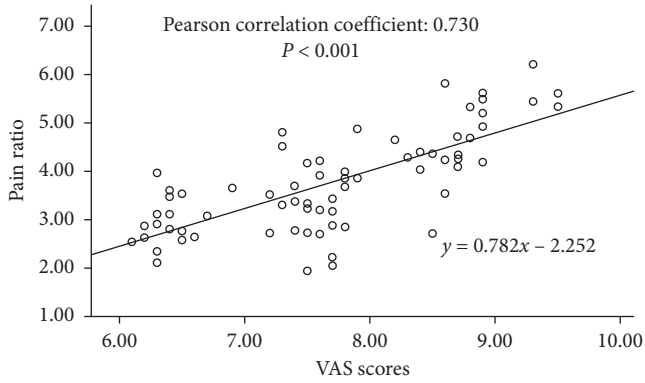

Figure 1: Pain vision system measured pain ratio before treatment was linearly correlated with patient VAS score.

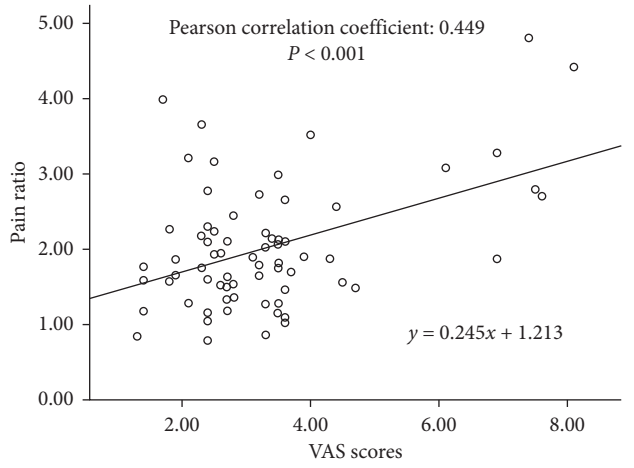

Figure 2: Pain vision system measured pain ratio after treatment was linearly correlated with patient VAS score.

pain, while C fibers transmit burning pain. Some studies have shown that A-delta fibers mainly sense shallow stimulation, which is more accurate and sensitive to signals such as pressure and tingling, and transmits nerve signals at a speed of 5–30 m/s. These fibers are also more sensitive to stimulation with a 250 Hz frequency. Class C fibers mainly sense nociceptive sensations such as pain and temperature, and transmit nerve signals at a speed of 0.5–2 m/s. They are more sensitive to stimulation with a frequency of 5 Hz [8, 9]. The pain vision system produces high frequency stimulating current, and no new pain is produced during the detecting period. Therefore, this instrument mainly stimulates the A-delta fibers, not C fibers, so it can only evaluate the pain degree of the A-delta fiber conduction [10].

The degree of pain was expressed by the ratio of CPT and PEC. Current perception threshold (CPT) refers to the minimum current value that can cause any sensation when current passes through the human body under certain conditions [11]. CPT measurement does not cause damage to the skin and subcutaneous tissue [12]. Pain equivalent current (PEC) is actually the current that continues to increase on the basis of current sensing threshold, when the patient's inherent "pain disappears" or "pain metastasis." Because the pain vision system mainly stimulates the A-delta fibers, the patients felt prickly pain at the test site.

Chronic pain, as a common type of pain, is a major global challenge affecting human health and quality of life. Being a painful disease, it affects about 20% of adults worldwide. Because of its complex etiology, clinical manifestations, high incidence, long treatment cycle, and relatively complex treatment process, it affects the quality of the daily life of patients. There are many studies on chronic pain in China, and they mostly are limited to the exploration of its physiology and pathology. As an important indicator of pain relief, the degree of pain is considered critical by clinical workers. As a subjective symptom of patients, it has been difficult to quantify whether or not the degree of pain has been reduced or how much it has been reduced.

There are many traditional methods of pain assessment, and domestic research has proved that the VAS method has high sensitivity, reliability, and validity than others [13]. Similar studies abroad have proved that the VAS method has the advantages of simplicity, convenience, and ease of operation and has become the most commonly used effective and reliable method for pain assessment [14]. Based on the VAS method, the pain vision system was used to test the pain degree of patients with chronic pain, and compared with the VAS method, to study the correlation between the two methods, and to make a reasonable explanation on whether the pain vision system can be used to evaluate chronic pain.

The final results of this study showed that the pain vision system can be used not only for the assessment of patients with chronic pain with high pain degree on admission, but also for the assessment of patients with low pain degree before discharge. However, the assessment effect of higher pain degree was better than that of lower pain degree (correlation with VAS was 0.730 and 0.449, respectively). The reasons are as follows: firstly, the pain was severe when the patient was admitted to hospital, and the actual value of equivalent current of pain (PEC) was relatively large and the error was relatively small. However, the patient's condition was relatively stable before discharge, the pain degree was relatively low, and the actual value of equivalent current of pain (PEC) was relatively small, so the error was relatively large. Furthermore, pain was completely relieved in some patients, and the equivalent current of pain perception (PEC) was very close to the value of current perception threshold (CPT). Due to the errors in patients' response during the two measurements, PEC was even less than CPT and even the pain ratio was less than 1 after treatment, which was theoretically impossible. Secondly, the pain of the patients was relieved after treatment and even completely disappeared. It was difficult to measure the accurate VAS

value in the VAS test, and even the VAS value before discharge was greater than that at admission. Of course, there are also some patients who do not have the need for pain relief when they are first admitted to the hospital, so there are errors that occur too casually during the test.

Pain vision system is a new pain measurement method. It objectively quantifies pain through neuroelectrophysiological pathways. It has the following advantages: (1) It does not damage skin and other tissues, and the measurement results can be repeated. (2) The operation is simple. The patients can press the button on their own without language description, so that the measurement is accurate. (3) The measurement results can be quantified and objectified. Of course, the pain vision system also has defects that make it impossible to replace the traditional means such as the VAS method completely. For example, due to its inability for stimulating C-type fibers, it cannot detect slow pain that C-type fibers conduct. Moreover, it requires that the patients must be present during the test, which is difficult to do sometimes. Some diseases affect nerve conduction, such as peripheral neuropathy, and will also have an impact on the measurement.

In conclusion, the pain vision system has a good correlation with the VAS score, which proves that the pain vision system can be used for pain measurement of chronic pain intensity. However, due to the small sample size, there may be some errors in this study. We look forward to further study in the future.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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