Do Severity Score and Skin Temperature Asymmetry Correlate with the Subjective Pain Score in the Patients with Complex Regional Pain Syndrome?

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Background:

The diagnostic criteria of complex regional pain syndrome (CRPS) have mainly focused on dichotomous (yes/no) categorization, which makes it difficult to compare the inter-patient's condition and to evaluate the intra-patient's subtle severity over the course of time. To overcome this limitation, many efforts have been made to create laboratory methods or scoring systems to reflect the severity of CRPS; measurement of the skin temperature asymmetry is one of the former, and the CRPS severity score (CSS) is one of the latter. However, there has been no study on the correlations among the CSS, temperature asymmetry and subjective pain score. The purpose of this study was to evaluate whether there is any correlation between the CSS, skin temperature asymmetry and subjective pain score.

Methods:

Patients affected with CRPS in a unilateral limb were included in this study. After making a diagnosis of CRPS according to the Budapest criteria, the CSS and skin temperature difference between the affected and unaffected limb (ΔT) was measured in each patient. Finally, we conducted a correlation analysis among the CSS, ΔT and visual analogue scale (VAS) score of the patients.

Results:

A total of 42 patients were included in this study. There was no significant correlation between the ΔT and VAS score (Spearman's rho = 0.066, P = 0.677). Also, the CSS and VAS score showed no significant correlation (Spearman's rho = 0.163, P = 0.303).

Conclusions:

The ΔT and CSS do not seem to reflect the degree of subjective pain in CRPS patients. (Korean J Pain 2014; 27: 339-344)

Key Words:

complex regional pain syndrome, infrared thermography, severity of illness index, visual analogue pain scale.

INTRODUCTION

Complex regional pain syndrome (CRPS) is a refractory pain disease that usually manifests after a minor injury [1]. CRPS is characterized by 4 categories of signs and symptoms: sensory change, vasomotor change, pseudomotor change, and motor change. The diagnosis of CRPS is based on examination of the presence of these signs and symptoms [2–4]. Since the diagnostic criteria for CRPS was established in the 1994 by International Association for the Study of Pain [5], several adjustments have been made by further studies, until the 2007 Budapest criteria was organized [2]. However, the Budapest criteria also have its weaknesses in that a simple dichotomous categorization method is not sufficient to examine interatient differences and identify the disease progress in a patient over the course of time [6,7]. In an effort to overcome these weaknesses, the CRPS severity score (CSS) was developed based on the Budapest criteria [8]. The CSS became a useful tool to compare the effect of treatment on a patient and to compare the severity of the disease among patients, which was not possible through the former dichotomous criteria. The CSS comprises a total of 17 items (8 items for patients' subjective symptoms and 9 items regarding the physical examination findings). Each checked item is counted as 1 point, and the total added score constitutes the CSS (Table 1).

Physicians make a diagnosis of CRPS by combining the patient's subjective symptoms and the objective signs. Hence, the objectivity of the diagnosis has been considered one of the most important factors to establish. To secure the objectivity of the diagnosis, several diagnostic criteria have been developed and a number of laboratory examinations have been used as complementary diagnostic tools. Infrared thermography (IRT) is a method for detecting abnormality by measuring the skin temperature. It has been widely used to complement the diagnostic process as it is noninvasive, user-friendly, and effective for visualizing the subjective pain. Skin temperature asymmetry greater than $1.0°$ C is considered significant [8], but other researchers have also suggested different temperature standards, such as $0.6°C$ [9] or $2.2°C$ [10].

Nevertheless, there has been no research on whether the CSS and degree of skin temperature asymmetry are viable in reflecting the severity of the patient's subjective symptoms. Thus, we aimed to examine whether the CSS and degree of skin temperature asymmetry have any correlation with the patient's subjective pain.

MATERIALS AND METHODS

This study was approved by the institutional review board of the authors' affiliated organization (IRB NO: B-1312/230-114). The inclusion criteria was the patients who had visited our pain center from March 2010 to August 2013 and had been diagnosed with CRPS in the ipsilateral limb based on the Budapest research criteria (Table 2) [2]. Of these patients, any patient with a history of sympathetic neurolysis, who had received a sympathetic block or epidural block within 3 months of the hospital visit, who had been administered ointment on the injured area, or who was taking vasodilators was excluded from the subject pool. The CSS was assessed and an IRT was performed on the participants. The IRT was performed in accordance with the method established in a previous study [11]: the patient was placed in a closed examination

Table 1. Diagnostic Signs and Symptoms Included in the Complex Regional Pain Syndrome Severity Score [8]

Self-reported symptoms	Signs observed on examination
Allodynia, Hyperpathia	Allodynia
Temperature asymmetry	Hyperpathia to pinprick
Skin color asymmetry	Temperature asymmetry by palpation
Sweating asymmetry	Skin color asymmetry
Asymmetric edema	Sweating asymmetry
Trophic changes	Asymmetric edema
Motor changes	Trophic changes
Decreased active range of motion	Motor changes
	Decreased active range of motion

Table 2. "Budapest Criteria" for Complex Regional Pain Syndrome [2]

To make the clinical diagnosis, the following criteria must be met:
1. Continuing pain, which is disproportionate to any inciting event
2. Must report at least one symptom in three of the four following categories:
   Sensory: Reports of hyperesthesia and/or allodynia
   Vasomotor: Reports of temperature asymmetry and/or skin color changes and/or skin color asymmetry
   Sudomotor/Edema: Reports of edema and/or sweating changes and/or sweating asymmetry
   Motor Trophic: Reports of decreased range of motion and/or motor dysfunction (weakness, tremor, dystonia) and/or trophic changes (hair, nail, skin)
3. Must display at least one sign **at time of evaluation** in two or more of the following categories:
   Sensory: Evidence of hyperalgesia (to pinprick) and/or allodynia (to light touch and/or temperature sensation and/or deep somatic pressure and/or joint movement)
   Vasomotor: Evidence of temperature asymmetry ($>1^{\circ}$C) and/or skin color changes and/or asymmetry
   Sudomotor/Edema: Evidence of edema and/or sweating changes and/or sweating asymmetry
   Motor/Trophic: Evidence of decreased range of motion and/or motor dysfunction (weakness, tremor, dystonia) and/or trophic changes (hair, nail, skin)
4. There is no other diagnosis that better explains the symptoms

For research purpose, diagnostic decision rule should be at least one symptom **in all four** categories and at least one sign (observed at evaluation) in two or more sign categories.

room with a constant temperature of 23°C, blocked from external light and heat. After 20 minutes of adaptation to the room, the patient was positioned 1 m from the IRT equipment IRIS$^{®}$– 5000 (Medicore Co., Korea) in an upright position. We then took infrared images of the frontal, posterior and lateral areas of the affected limb, its symmetrical region on the other limb, and the sole (according to our needs).

For evaluation of the IRT images, the skin temperature of the area of the patients' most severe pain and the symmetrical area on the other limb were measured, and the ⊿T was calculated. The CSS and visual analogue scale (VAS) scores were calculated as well. The VAS score was measured using a 10 cm–long tool and the range of the scale was from 0 with "no pain", to 10 with "the worst possible pain ever imagined". The ⊿T was defined as follows.

$$⊿T = | \text{ Skin temperature of the affected area} - \text{Skin temperature of the unaffected symmetrical area } |$$

For the statistical analysis, IBM SPSS statistics$^{®}$ version 17.0 (IBM Corporation, NY, USA) was used and a Shapiro–Wilk test was used to perform a normality test on the ⊿T, CSS and VAS scores. In cases that showed abnormal distribution, Spearman's non–parametric correlation analysis was performed. The primary outcome was set as the correlation between the ⊿T and VAS score, and the secondary outcome was set as the correlation between the

Table 3. Demographic Data of Patients

Parameter	Value
Sex (M/F)	37/5
Age (years)	25.4 ± 10.0
CRPS type (1/2)	37/5
Site (UE/LE)	9/33
Temperature difference ($^{\circ}$C)	3.0 ± 2.3
Visual analogue scale score (10 cm)	7.6 ± 1.7
CRPS severity score	11.7 ± 2.8

UE: upper extremity, LE: lower extremity, CRPS: complex regional pain syndrome.

CSS and VAS score. *P* values of less than 0.05 were determined to be significant.

RESULTS

A total of 42 patients participated in this study, and the demographic data is illustrated in Table 3. The ⊿T calculated from the IRT measurement was 3.0 ± 2.3°C; the VAS score (10 cm) was 7.6 ± 1.7, and the CSS was 11.7 ± 2.8. The distribution of the VAS score, CSS and ⊿T is shown in Fig. 1.

The Spearman's rho of the correlation analysis of the ⊿T and VAS score was 0.066 (P = 0.677) with no significant correlation. There also was no significant correlation between the CSS and VAS score (Spearman's rho =
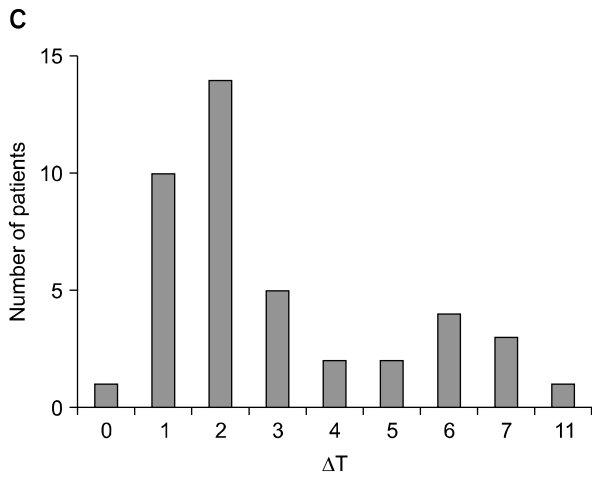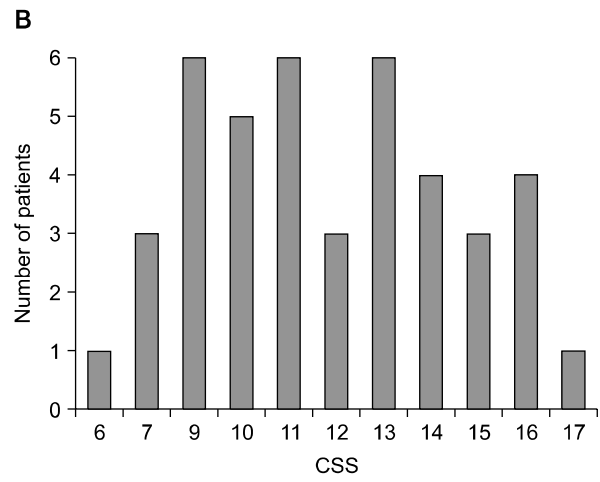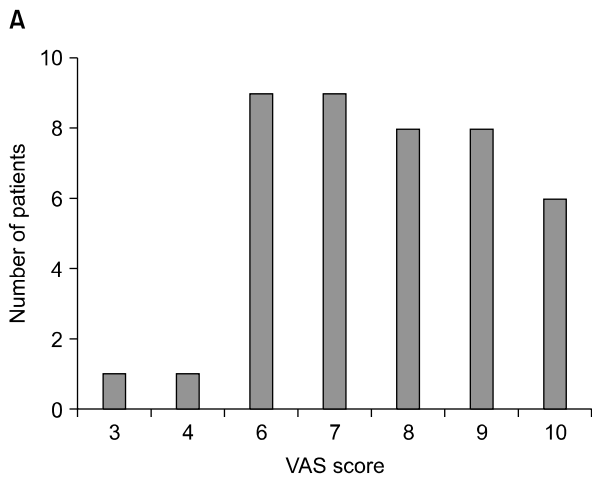
A

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Fig. 1. Distribution of visual analogue scale (VAS) score, complex regional pain syndrome severity scores (CSS), and skin temperature difference (⊿T).
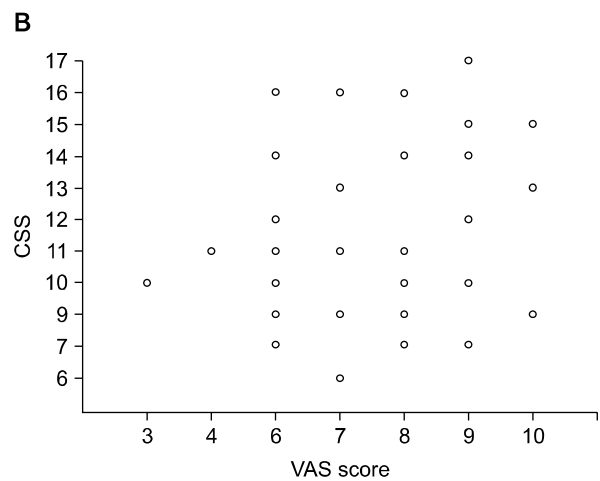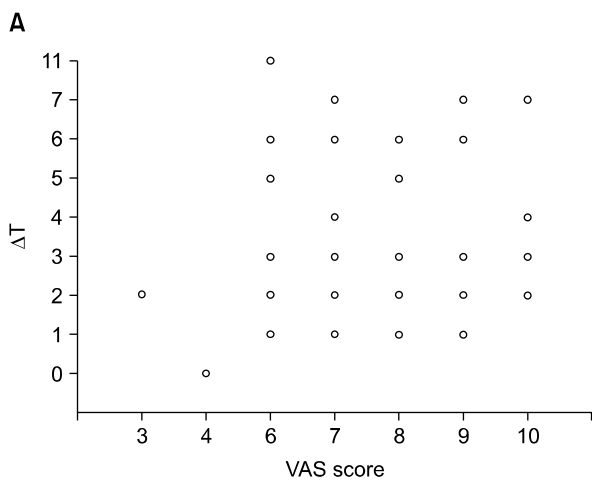
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Fig. 2. Scatter plot of the variables. (A) Visual analogue scale (VAS) score and skin temperature difference (⊿T) (Spearman's rho = 0.066, P = 0.677). (B) VAS score and complex regional pain syndrome severity score (CSS) (Spearman's rho = 0.163, P = 0.303).

0.163, P = 0.303). The distribution of these three variables is illustrated in a scatter plot in Fig. 2.

DISCUSSION

As the pathophysiologic etiology of CRPS has not yet been determined, the diagnosis is based on signs and symptoms [4]. Likewise, even the most widely used CRPS diagnostic criteria—the Budapest criteria—is based on patients' subjective pain, as it is used to determine the presence of sensory change, vasomotor change, pseudomotor change, and motor change [2]. The presence of subjective pain is the most fundamental checklist item in the diagnosis of CRPS. In other words, CRPS cannot be diagnosed without a patient's perception of pain. Because the presence or the severity of pain cannot be directly objectified in any case, several studies have attempted to find an objective method indirectly related to the presence or severity of pain. Pleger et al. [12] reported that following behavioral treatment, CRPS patients experienced a decrease in pain and an increase in the 2-point discrimination thresholds as well as a concurrent change in the cortical map size of their primary and secondary cortex. Moreover, Kemler et al. [13] tried to establish a correlation between the degree of vasodilation measured using laser doppler flowmetry and pain mitigation effects of spinal cord stimulators, but failed to discover any significant correlation. Similarly, this study did not find any specific correlation between the CSS and VAS score, and also $\varDelta$T and VAS score, indicating that the CSS and $\varDelta$T do not offer objective representations of subjective pain.

Although the indicators of severity are not measurements with absolute objectivity, they are recognized as methods that can offer a certain degree of objectivity in classifying patients or determining the effects of treatment. Therefore, the suggested CSS is used in the clinical practice. The CSS comprises 17 criterias corresponding with the signs and symptoms and includes all the Budapest criteria which is highly related to the currently-used CRPS diagnostic criteria. It is supposed that the higher the CSS, the higher the pain intensity, emotional stress and impaired function, which restricts movement and induces a large difference in the skin temperatures of both limbs [8].

However, we could not find any significant correlation between the CSS and VAS score and also between CSS and $\varDelta$T. This may have resulted because CRPS is affected by several factors including peripheral, central, sympathetic mechanism and emotional factors [14,15]. And, because of these different influential factors, the difference in skin temperature between both limbs and the VAS score can be affected. Therefore it cannot determine the overall severity of CRPS.

There are various opinions on the relationship between CRPS and temperature difference. Some studies have reported that the early stages of CRPS display a "warm regulation type", which turns into a "cold regulation type" as the conditions become chronic [16,17], while others argue that the duration of the disease is irrelevant [18]. As mentioned before, the temperature difference is an important factor in the diagnosis of CRPS, although it is difficult to set a standard of a certain temperature. Therefore, the $\varDelta$T can vary greatly at various points in time, so that the degree of temperature asymmetry alone is insufficient to be used as a scale for the severity of the disease. Krumova et al. [10] reported that when the skin temperature is measured, the specificity is higher for the difference in the skin temperature reactions to external temperature changes than for the absolute skin temperature changes in CRPS patients. There were attempts to measure the body's changes of reaction to cold stress tests based on these results and to use them in the diagnosis of CRPS [19,20].

This study used an absolute value for the analysis instead of an actual value measured by thermography. This decision was based on previous study results showing that an absolute value is diagnostically more valuable in the diagnosis of CRPS than the actual value of the patients' skin temperature differences [21].

This study had limitations in that the sample size was small. However, it still holds great significance given the fact that it is difficult to recruit CRPS patients due to the rarity of the disease. Furthermore, because the correlation coefficients between the variables of this study were very low (0.066–0.163), it is proper to believe that a larger sample size would not display a higher correlation effect.

In conclusion, there was no correlation between CRPS patients' subjective pain, degree of skin temperature asymmetry and CSS. The degree of skin temperature asymmetry and CSS do not represent the severity of patients' subjective pain and should be cautious in evaluating CRPS patients.

REFERENCES

1. Shin HY, Choi YM, Nahm FS, Park SJ, Koo MS, Suh JH, et al. Comparison of the two impairment classes publicized by the American Medical Association in complex regional pain syndrome patients. Korean J Pain 2007; 20: 148-53.
2. Harden RN, Bruehl S, Stanton-Hicks M, Wilson PR. Proposed new diagnostic criteria for complex regional pain syndrome. Pain Med 2007; 8: 326-31.
3. Harden RN, Bruehl SP. Diagnosis of complex regional pain syndrome: signs, symptoms, and new empirically derived diagnostic criteria. Clin J Pain 2006; 22: 415-9.
4. Harden RN. Objectification of the diagnostic criteria for CRPS. Pain Med 2010; 11: 1212-5.
5. Stanton-Hicks M, Jänig W, Hassenbusch S, Haddox JD, Boas R, Wilson P. Reflex sympathetic dystrophy: changing concepts and taxonomy. Pain 1995; 63: 127-33.
6. Bruehl S, Harden RN, Galer BS, Saltz S, Backonja M, Stanton-Hicks M. Complex regional pain syndrome: are there distinct subtypes and sequential stages of the syndrome? Pain 2002; 95: 119-24.
7. de Mos M, de Bruijn AG, Huygen FJ, Dieleman JP, Stricker BH, Sturkenboom MC. The incidence of complex regional pain syndrome: a population-based study. Pain 2007; 129: 12-20.
8. Harden RN, Bruehl S, Perez RS, Birklein F, Marinus J, Maihofner C, et al. Development of a severity score for CRPS. Pain 2010; 151: 870-6.
9. Bruehl S, Lubenow TR, Nath H, Ivankovich O. Validation of thermography in the diagnosis of reflex sympathetic dystrophy. Clin J Pain 1996; 12: 316-25.
10. Krumova EK, Frettlöh J, Klauenberg S, Richter H, Wasner G, Maier C. Long-term skin temperature measurements — a practical diagnostic tool in complex regional pain syndrome. Pain 2008; 140: 8-22.
11. Choi E, Lee PB, Nahm FS. Interexaminer reliability of infrared thermography for the diagnosis of complex regional pain syndrome. Skin Res Technol 2013; 19: 189-93.
12. Pleger B, Tegenthoff M, Ragert P, Förster AF, Dinse HR, Schwenkreis P, et al. Sensorimotor retuning [corrected] in complex regional pain syndrome parallels pain reduction. Ann Neurol 2005; 57: 425-9.
13. Kemler MA, Barendse GA, van Kleef M, Egbrink MG. Pain relief in complex regional pain syndrome due to spinal cord stimulation does not depend on vasodilation. Anesthesiology 2000; 92: 1653-60.
14. Ciccone DS, Bandilla EB, Wu W. Psychological dysfunction in patients with reflex sympathetic dystrophy. Pain 1997; 71: 323-33.
15. Geertzen JH, de Bruijn-Kofman AT, de Bruijn HP, van de Wiel HB, Dijkstra PU. Stressful life events and psychological dysfunction in Complex Regional Pain Syndrome type I. Clin J Pain 1998; 14: 143-7.
16. Niehof SP, Huygen FJ, van der Weerd RW, Westra M, Zijlstra FJ. Thermography imaging during static and controlled thermoregulation in complex regional pain syndrome type 1: diagnostic value and involvement of the central sympathetic system. Biomed Eng Online 2006; 5: 30.
17. Birklein F, Riedl B, Claus D, Neundörfer B. Pattern of autonomic dysfunction in time course of complex regional pain syndrome. Clin Auton Res 1998; 8: 79-85.
18. Veldman PH, Reynen HM, Arntz IE, Goris RJ. Signs and symptoms of reflex sympathetic dystrophy: prospective study of 829 patients. Lancet 1993; 342: 1012-6.
19. Park EJ, Han KR, Chae YJ, Jeong WH, Kim C. Effectiveness of cold stress thermography in the diagnosis of complex regional pain syndrome type 1. Korean J Pain 2006; 19: 159-63.
20. Gulevich SJ, Conwell TD, Lane J, Lockwood B, Schwettmann RS, Rosenberg N, et al. Stress infrared telethermography is useful in the diagnosis of complex regional pain syndrome, type I (formerly reflex sympathetic dystrophy). Clin J Pain 1997; 13: 50-9.
21. Nahm FS, Lee PB, Park SY, Kim YC, Lee SC. Comparison of the diagnostic validity of real and absolute skin temperature differences for complex regional pain syndrome. Korean J Pain 2009; 22: 146-50.