Evaluation of pain intensity measurement during the removal of wound dressing material using ‘the PainVision™ system’ for quantitative analysis of perception and pain sensation in healthy subjects

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ABSTRACT

Reducing pain caused by the removal of adhesive wound dressing materials is very important in clinical practice and is also one of the factors to consider when choosing dressing materials. A visual analogue scale is the most popular method for assessing pain, but it is subjective and is difficult to evaluate quantitatively or statistically. Recently, a new method for the quantitative measurement of pain intensity using a painless electrical stimulation system, PainVision™, has been developed. In this study, we evaluated pain intensity during the removal of wound dressing materials in healthy volunteers by comparing pain during the removal of wound dressing materials, which use acrylic pressure-sensitive adhesive and pain during the removal of materials, which use soft silicone adhesive, as evaluated using the PainVision™ system. Pain intensity was significantly lower with the dressing materials, which use soft silicone adhesive when measured with the PainVision™ system. The PainVision™ system promises to be useful for the quantitative assessment of pain caused by the removal of adhesive wound dressing materials. Further studies are needed to determine whether the PainVision™ system is also effective in measuring pain caused by the removal of wound dressing materials in actual wounds.

Key words: Acrylic pressure-sensitive adhesive • Pain • PainVision™ • Soft silicone adhesive • Wound dressing

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Key Points

- Pain is a sensation associated with subjective factors and is, therefore, difficult to measure and assess.
- The PainVision™ system is a device capable of quantitative assessment by substituting pain with different sensory stimulation, has been developed and used mainly in the field of anesthesiology and in pain clinics in Japan.
- In this study, we investigated whether pain caused by the removal of various wound dressing materials can be assessed objectively in healthy volunteers with this PainVision™ system by the quantitative analysis of perception and pain sensation, and by comparing the degrees of pain during the removal of wound dressing materials.
- We enrolled 10 healthy volunteers, five men (age: 24–48 years) and five women (age: 22–33 years) with a mean age of 32.4 years.

INTRODUCTION

Wound dressing materials are frequently used in clinical practice. However, the removal of some of these wound dressing materials can cause significant pain and discomfort to patients. Recently, for the adhesive agents used in wound dressing materials, soft silicone adhesive as well as conventional acrylic pressure-sensitive adhesive have been commonly used (1–3). The silicone adhesive is characterised by improved apposition of wounds, and it relieves pain during the removal of the wound dressing material by reducing the abrasion of epithelial cells from the skin (1–3).

However, pain is a sensation associated with subjective factors and is, therefore, difficult to measure and assess (4–6). Accordingly, subjective assessment methods such as the use of the visual analogue scale (VAS) (7) or face pain rating scale (FPRS) (8) have been mainly used. Improvement in wound dressing materials in terms of reduction of pain during removal has also been assessed subjectively; however, to the best of our knowledge, no objective assessment has been performed.

In recent years, the PainVision™ system (PS-2100, Nipro Corporation, Osaka, Japan), a device capable of quantitative assessment by substituting pain with different sensory stimulation, has been developed and used mainly in the field of anesthesiology and in pain clinics in Japan (5,6). In this study, we investigated whether pain caused by the removal of various wound dressing materials can be assessed objectively in healthy volunteers with this PainVision™ system by the quantitative analysis of perception and pain sensation, and by comparing the degrees of pain during the removal of wound dressing materials.

MATERIALS AND METHODS

We enrolled 10 healthy volunteers, five men (age: 24–48 years) and five women (age: 22–33 years) with a mean age of 32.4 years. Various adhesive wound dressing materials were applied to a hairless part of the left medial forearm. Subsequently, pain caused by removal was measured with the PainVision™ system (Figure 1).

The specific methods were as follows. First, sensors transmitting an electric current were attached to the right medial forearm. The current perception threshold that indicated the pain threshold of each subject was measured three times, and the mean values were used as the measurements. Second, the pain-compatible electrical current was measured as indicated below. Various adhesive wound dressing materials were applied to a hairless part of the left forearm. While the dressing materials were being removed at a rate of approximately 1 cm/second (total removal time = approximately 10 seconds), a gradually increasing pulsed current was applied to the right medial forearm. The pain due to the dressing removal and the magnitude of electric stimulation were believed equal, the current was defined as the pain-compatible electrical current. The pain-compatible electrical current was measured three times, and the mean values were used as the measurements. On the basis of these measurements, pain intensity was calculated using the following equation:

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Pain\ intensity = 100 \times \frac{(pain-compatible\ electrical\ current - current\ perception\ threshold)}{current\ perception\ threshold}.\]  \hspace{1cm} (1)

At the same time, VAS scores (range, 1–100 mm) were obtained during the removal of each wound dressing material.

The adhesive wound dressing materials used in the experiment were as follows. Material A, a highly adhesive wound dressing material, which uses acrylic pressure-sensitive adhesive; material B, a highly adhesive wound dressing material, which uses soft silicone adhesive (an upgraded version of material A); material C, a highly adhesive wound dressing material, which uses soft silicone adhesive; and material D, a less adhesive wound dressing material, which uses soft silicone adhesive. Statistical analyses were performed with the Student’s t-test, and P values of 0.05 or less were considered to represent statistically significant differences.

RESULTS

Each measurement was very simple and could be completed in a few seconds. The results were stored in the hard disk of a personal computer connected to the PainVision™ system or...
The mean current perception threshold was 9.35 µA, and tended to be higher in men (11.71 µA) than in women (7.09 µA). The pain intensity was 78.1 µA for material A, 11.5 µA for material B, 16.9 µA for material C and 17.0 µA for material D (Figure 2).

A statistically significant difference in pain intensity was observed between material A and materials B, C and D ($P < 0.05$). On the other hand, there was no statistically significant difference in pain intensity among materials B, C and D ($P < 0.05$). The concurrently measured VAS scores were 10.3 mm for material A, 5.4 mm for material B, 5.9 mm for material C and 1.6 mm for material D. Although the VAS score for material A was significantly higher than those for the other materials on assessment ($P < 0.05$), 8 of 10 volunteers reported difficulty in describing pain intensity with numerical values compared with describing ‘current perception threshold’ and ‘pain-compatible electrical current’ in pain assessment using PainVision™ system (Figure 3).

**DISCUSSION**

Current pain assessment methods include the VAS (7) and FPRS (8), but both are subjective methods (4–8). In these methods, the intensity of current pain is determined by comparing the reported pain level with a ‘pain of maximum intensity’ value. However, because sensitivity to pain varies greatly among individuals, it is difficult to quantitatively compare measurements obtained by these methods. Moreover, the comparison of measurements for relatively weak pain is even less reliable.

PainVision™, a system for the quantitative analysis of perception and pain, which has recently started to be used in the field of pain and anesthesiology (5,6), gives patients alternative painless sensory stimulation equivalent to pain (mainly by stimulating sensory nerve fibres Aβ and Aδ) and measures the intensity of the stimulation (5,6). Because individual pain thresholds are evaluated first to provide accurate subsequent measurement with the device, pain intensity can be quantitatively compared among patients. The device has been used in studies on persistent chronic pain such as herpes zoster-associated pain (6). To the best of our knowledge, although no study has investigated the measurement of procedural pain...
Key Points

- the pain intensity that was measured with the PainVision™ system and the quantitative analysis of perception and pain sensation during the removal of wound dressing materials was very similar to that reported by subjects
- the system also enabled the quantification and comparison of pain intensity, uninfluenced by individual pain thresholds
- because of its short measurement time and highly reproducible measurements, the PainVision™ system promises to be effective for quantifying various kinds of pain
- the assessment of procedural pain may also be possible thus, the PainVision™ system may be highly applicable to other fields in the future

with this device such as pain caused by the removal of wound dressing materials as investigated in this study, we observed that pain lasting for a certain time could be adequately measured with the PainVision™ system.

Recently, the performance of recent wound dressing materials has improved remarkably, and current versions are highly functional in sustaining a moist wound environment, promoting wound healing, controlling exudative material and acting as a barrier against the external environment. In addition, they have antibacterial properties. However, with these improvements, further reduction of pain has become desirable for wound dressing materials. Thus, although materials that use acrylic pressure-sensitive adhesive have been predominant, products using soft silicone adhesive have recently become available and have yielded improvement in wound apposition and reduction of the pain caused by the removal of dressing materials (1–3).

In this study, pain intensity associated with the wound dressing materials that use acrylic pressure-sensitive adhesive was significantly higher than that associated with the wound dressing materials that use soft silicone adhesive, confirming the recent improvements in wound dressing materials. The pain intensities quantitatively measured in this study were nearly similar to the levels reported by the subjects and were, therefore, considered to be highly reliable. Moreover, the removal of wound dressing materials that use soft silicone adhesive has been known to cause less abrasion of epidermal cells from the skin (1,3), a finding which was confirmed in the results of this study.

Because most of the concurrently measured VAS scores were approximately 10 mm or less (range, 0–100 mm), the pain caused by the removal of wound dressing materials was considered to be relatively weak. With regard to pain intensity, similar VAS scores to the measurements obtained with the PainVision™ system for each material were observed. However, most of the volunteers reported difficulty in describing a different intensity of pain caused by the removal of each material using numerical values. Thus, compared with conventional assessment methods such as the VAS, the PainVision™ system can be considered to be more sensitive, and it may enable objective quantitative assessment of even relatively mild pain.

The adhesive agent used for material D is weaker and has a lower peel force than those used for other wound dressing materials. However, the difference in pain intensity was not apparent between material D and other materials, which use soft silicone adhesive. This suggests that deep pain sensations may not easily be quantified, because the PainVision™ system measures pain on the skin surface.

This study has some limitations, such as the small number of subjects in a single institution. Furthermore, its efficacy was not tested in the pain of actual patients, only in healthy subjects. However, the results of this study indicated the useful quantitative measurement of pain caused by the removal of wound dressing materials. Further studies will be needed to determine whether the PainVision™ system is also effective in measuring pain caused by the removal of wound dressing materials in actual wounds.

CONCLUSION

The pain intensity that was measured with the PainVision™ system and the quantitative analysis of perception and pain sensation during the removal of wound dressing materials was very similar to that reported by subjects. The system also enabled the quantification and comparison of pain intensity, uninfluenced by individual pain thresholds. Because of its short measurement time and highly reproducible measurements, the PainVision™ system promises to be effective for quantifying various kinds of pain. The assessment of procedural pain may also be possible. Thus, the PainVision™ system may be highly applicable to other fields in the future.

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