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Scientific/Clinical Article

Cold intolerance after nerve injury

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ABSTRACT

Cold intolerance after nerve injury can be severe and has been associated with high levels of pain and disability. This article provides an overview of the assessment and nonoperative management of cold-induced symptoms after peripheral nerve injury. A comprehensive evaluation should include both objective measures such as skin temperatures and subjective tools to assess the patient's perspective and impact of the symptoms. Management of the patient with cold intolerance remains challenging and should include adaptive strategies, warming interventions, and desensitization conditioning programs to minimize cold-induced pain and hyperresponses.

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Introduction

Cold intolerance is defined as an atypical response to cold exposure that results in pain, sensory alteration, stiffness, and/or color changes and may occur following a traumatic injury.¹ Cold intolerance after nerve injury can be severe and has been associated with high levels of disability. The terms cold intolerance and cold sensitivity have been used extensively and interchangeably in the hand therapy/surgery literature to clinically describe these abnormal cold-induced responses. This article will provide an overview of the approaches to assessment and nonoperative management of cold-induced symptoms after peripheral nerve injury.

Persistent cold intolerance, particularly cold-induced pain, in patients with hand, nerve, and amputation injuries has been associated with poor outcomes.^{1–7} The occurrence of cold-induced symptoms following upper extremity trauma reported in the literature varies from 38% to 87%, and the wide range of occurrence may relate to the selected patient samples, diagnoses, and etiologies assessed. In our investigation of the prevalence of cold intolerance, we assessed patients with a variety of upper extremity pathologies and 34% of patients reported cold-induced pain with a significantly higher prevalence following traumatic injury; trauma (40%) and

nontrauma (27%).⁸ In trauma patients, the significant predictor of more severe cold-induced symptoms was time since injury, indicating that severe cold-related pain is long standing. In our study of patients with chronic nerve compression, there were 52% who reported cold-induced symptoms, and cold intolerance was significantly more frequent in women and those with diabetes.⁹ In a study comparing patients with carpal tunnel syndrome and healthy controls, cold detection thresholds were significantly lower with severe carpal tunnel syndrome, suggesting the involvement of small sensory fibers.¹⁰ A previous study investigated patients after nerve injury, and 76% of patients had cold sensitivity with the majority reporting moderate to severe symptoms.² A study of patients with upper extremity trauma after arterial repair reported 41% of patients with persistent cold intolerance and more frequent in patients with a previous nerve lesion.¹¹ In a review of patients with neuropathic pain from a variety of etiologies including traumatic nerve injuries, cold provocation induced the highest pain intensity.¹² Overall, there is a high prevalence of cold-induced symptoms after upper extremity trauma and particularly following nerve injury. There have been some reports of decreasing cold intolerance over time; however, the majority of patients with nerve injury will continue to have persistent cold intolerance.^{2,13} The problem of cold-induced symptoms extends beyond upper extremity nerve injury and trauma. Other studies have reported cold hyperalgesia with whiplash-associated disorders and relationship with persistent pain and prolonged disability.^{14,15} Cold intolerance continues to be a substantial clinical challenge, and the mechanisms remain largely unknown.

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Evaluation

Many clinically administered and patient-reported assessment tools have been described to assess cold intolerance, such as physical assessments, rating scales, and self-reported questionnaires.^{2,7,16-21} Objective tests to assess cold-induced responses, such as skin temperature with cold exposure, rewarming patterns, and arterial pressures, have typically utilized cold water immersion as the cold stress. These assessments of the vascular status provide 1 component of the cold-induced response but do not evaluate the pain, cold symptoms, and/or impact experienced by the patient.^{4,21,22} Self-report questionnaires such as the Cold Sensitivity Scale (CSS), the Cold Intolerance Symptom Scale (CISS), and the Cold Specific Functional Scale utilize patient self-report to rank cold-induced symptoms on numeric scales.^{8,19,20,23} The CSS was developed to evaluate the severity of cold-induced symptoms and the impact on activities and work. It includes 4 cold-related tasks (holding a glass of cold water, getting out of a hot shower or bath, holding a frozen package, and washing in cold water) that the patient ranks on a 5-point Likert scale (not at all to extreme) as to how much they are bothered by the cold. The CISS has specific questions regarding cold-induced symptom severity, the impact on daily activities and includes the CSS task items. The CISS has been widely used to evaluate cold intolerance after upper extremity trauma, and studies have shown moderate association with pain intensity and disability (disabilities of the arm, shoulder and hand).^{5,6,24,25} A CISS score of 30 is generally accepted as the criterion for abnormal cold intolerance.²⁰ Evaluating the CISS scores in patients with nerve injury (>6 months), we found high levels of pain, cold intolerance, and impact on quality of life and moderate association with impact on quality of life.²⁶ In patients selecting a single adjective of “coldness,” there were significantly higher CISS scores, pain, and impact on quality of life. To assess overall functional status, the Patient Specific Functional Scale was developed to assess the function based on specific tasks that are identified by the patient as difficult or unable to do.²⁷ For each item, the patient ranks the degree of difficulty on a numerical scale from 0 to 10. The Patient Specific Functional Scale provides insight into the specific tasks or activities that are important to the patient with hand-related pathologies.^{28,29} We have modified the Patient Specific Functional Scale questionnaire to include impairment of tasks related to cold-induced symptoms (Fig. 1) and have found it extremely useful for individual assessment of cold intolerance.⁸ Patients are asked to rank symptoms related to cold air and water exposure and specific tasks. Studies have reported varying factors related to persistent and severe cold intolerance, including type of injury, nerve or bone injury, amputation, sensory recovery, and time since injury, but there is little consensus on the predictors of cold intolerance after injury.^{5,6,18,23,30-32} Evaluation of patients with traumatic nerve injury should include screening questions regarding cold-induced symptoms and a more comprehensive evaluation in those patients who report cold-induced symptoms to identify potential sources of pain and targets for intervention.

Cold water immersion and cold air exposure are typically the cold stressors used to assess cold intolerance. Variation in the cold stress utilized and administered in the assessment of cold-induced symptoms may influence both the physiological and subjective responses. A review of the cold stress tests for the evaluation of vascular disorders in vibration syndromes revealed wide variation in the methods of skin temperature measurement and for water immersion, the water temperature used, and the duration of immersion.³³ Assessment of the vascular status included skin temperature, finger systolic blood pressure, and thermography. Most studies assessing cold intolerance have utilized water immersion as the cold stress and assessed skin temperature before immersion

When your hand is exposed to cold temperatures, do you have symptoms of pain or a sense of severe cold in your hand?

No _____ Mild _____ Moderate _____ Severe _____

Cold Specific Function Scale

List 3 situations or activities that cause or increase your cold related problem or symptoms. Rank each item from 0 to 10 (with 0 being no symptoms and 10 most severe).

1. _____

Please rate your symptoms with this item (circle number).

0 1 2 3 4 5 6 7 8 9 10
None Most Severe

2. _____

Please rate your symptoms with this item (circle number).

0 1 2 3 4 5 6 7 8 9 10
None Most Severe

3. _____

Please rate your symptoms with this item (circle number).

0 1 2 3 4 5 6 7 8 9 10
None Most Severe

Fig. 1. The Cold Specific Functional Scale allows the patient to identify specific actions or tasks that induce cold-related symptoms or pain. Each item is ranked on a scale from 0 to 10. Reproduced with permission from: Christine B. Novak, PT, PhD.

and after removal of the extremity from the water. The temperature of the water in these studies has varied from 5°C to 12°C for a duration of 5-10 minutes. Because cold stress tests can be painful with increasing pain as the temperature decreases and duration of exposure increases, efforts have been directed toward obtaining the most comprehensive assessment with the least amount of discomfort, thus increasing the water temperature for the shortest exposure duration. Despite these efforts, studies have not established the relationship between vascular status and cold-induced symptoms of cold intolerance. In studies related to hand trauma, cold water immersion often is utilized at a temperature of 12°C for 5 minutes, and some studies have used shorter durations of immersion. Using this established protocol of water immersion, Traynor et al²¹ assessed the relationship between skin temperatures and self-report in healthy subjects and found both assessments were reliable. However, there was no association between the skin temperatures as measured by infrared thermometers when the hand was removed from the water and self-reported symptoms. In another study, the infrared thermometer was shown to have good reliability for the assessment of digit skin temperatures.³⁴ Although both objective and subjective evaluation offer valid and reliable assessments, each type of evaluation likely provides information regarding different components of the complex construct of cold-induced responses. Comprehensive evaluation should include both physical measures and subjective report using valid and reliable measurement tools.

The method of cold stress may impact the results, and exposure to cold water vs cold air may elicit different responses.³⁵ We have utilized both cold air exposure and cold water immersion with continuous skin temperature monitoring to evaluate cold-induced responses. Cold water immersion (5°C) induces a rapid decline in skin temperatures and vasoconstriction, and many patients report a high intensity of discomfort. We have utilized moderate cold air exposure (1°C) for 20 minutes to induce cold responses and used continuous skin temperature monitoring. In our pilot study of

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