Diagnostic Significance of Cold Provocation Test at 12°C

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Abstract

In Germany, vibration-induced white finger (VWF) disease is accepted as an occupational disease (BK No. 2104 BKV), for which compensation may be paid provided that the sociolegal requirements are met in accordance with the list of occupational diseases that is valid at the time. A cold provocation test (thermometry, infrared thermography) is helpful in the diagnosis of VWF and we believe that it could contribute to the standardization of vascular assessment methods. In Germany, the approved degree of the decrease in earning power is downgraded as disease symptoms improve with time; therefore, insured individuals suffering from VWF are regularly reassessed every 1–3 years. In the context of such follow-up examinations and the assessment of reversibility of this disease, a standardized cold provocation test is of central importance. Currently, there is a lack of data that confirm the diagnostic value of this test. Further investigations on VWF patients to validate the use of the cold provocation test in obtaining sufficient data for determining the satisfactory diagnostic value of this test are required.

Key words: cold provocation test, thermometry, infrared thermography, vibration-induced white finger, occupational disease

Introduction

In Germany, vibration-induced white finger (VWF) is accepted as an occupational disease (BK No. 2104 BKV), for which compensation may be paid provided that the sociolegal requirements are met in accordance with the list of occupational diseases that is valid at the time. The amount of financial compensation reflects the total decrease in earning power (MdE). For the disease to be recognized as an occupational illness, occupation-induced medical conditions need to be fulfilled. An important factor in the diagnostic decision making with respect to VWF is the cold provocation test in addition to a detailed patient history together with standardized pallesthesiometric examinations.

The cold provocation test can be applied as a sensitive test for determining the thermoregulation of the skin. For this reason, the skin temperature of fingers needs to be measured as an indirect parameter of peripheral circulation. The vascular reaction may be graphically pictured, e.g., by acral measure-

ments using acral thermometry and thermography (1). The acral parts of all ten fingers have to be placed into contact with sensitive thermosensors for skin temperature to be measured ("thermometry").

Thermography is an image-creating test for the indirect documentation of perfusion conditions, demonstrating heat radiation from the hands including the entire lengths of fingers. Heat radiation is recorded using an infrared camera. Infrared radiation that originates from the body is proportional to surface temperature. The result is a thermic map (2).

Method of cold provocation test (thermometry, thermography)

Thermometric analyses, which were carried out at the Institute of Occupational, Social and Environmental Medicine at the University of Mainz, were designed such that they allowed a simultaneous detection of signals from the ten finger tips via thermosensors that were placed in the middle of individually adjustable plastic rings. Temperature was measured automatically every 10 to 20 sec and the temperature time course was displayed on a monitor (Fig. 1).

Moreover, an infrared thermographic system was used. This system consists of a sensor head equipped with a mirror, an operating element, a display unit, a picture memory unit and a color monitor, which allows for quantitative analyses through

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Fig. 1 Example of different rewarming profiles of fingertips of right hand (thermometry). Reaction outcomes: N, normal; mV, moderately delayed; sV, severely delayed.

the display of thermographic pictures in 16 different colors (3).

Until March 2003, conventional cold provocation tests at the University of Mainz (Institute of Occupational, Social and Environmental Medicine) were performed for 2 min in a cold water bath at 12°C. The water temperature and duration of exposure were chosen on the basis of experiments that had been carried out in the 1980s by Dupuis and colleagues. Cold provocation tests were at that time carried out on 20 young and healthy students, who were between 21 and 33 years old. The tests were conducted at water temperatures of 8, 12, 14 and 16°C for various exposure times between 5 sec and 5 min. These experiments led to the conclusion, that a water bath temperature of 12°C and an exposure time of 2 min are appropriate for cooling the subjects' fingers sufficiently, such that the differentiation among normal, moderately delayed and severely delayed rewarming temperature courses is feasible (4).

In 1986, Dupuis identified three types of probable reaction outcome as follows. "N" is a normal reaction (skin temperature is at least 28°C within 15 min after the end of the cold provocation) (fingers R1 and R2 in Fig. 1). "mV" is defined as a moderately delayed rewarming (skin temperature of at least 28°C is reached within the 16th and 25th min after the end of the cold provocation) (finger R4 in Fig. 1). "sV" is a severely delayed rewarming, in which 28°C was not attained by the end of the test (finger R5 in Fig. 1) (2). A more precise differentiation of assessment did not seem to be possible.

From 1988 to March 2003, the cold provocation test was carried out on 376 patients after a 2-min exposure to cold water at 12°C at the Institute of Occupational, Social and Environmental Medicine, University of Mainz. Skin temperature was measured for 28 min at the most after the end of exposure to cold water.

Advantages of thermometric and thermographic assessment methods

Thermometry is a convenient method, which may easily be used in practice from an occupational medicine perspective, which allows for the diagnosis of peripheral vibration-induced

disturbances. The simultaneous assessment of 10 fingers by thermometry may be helpful in differential diagnoses, for example, that of hypothenar hammer syndrome.

The thermography system is a time-dependent method, which is skin-contact-free and allows for a simultaneous graphic display of both hands in one session. The visual imaging of temperature over the affected skin area provides important diagnostic details such as temperature distribution over the entire lengths of fingers as an indicator of peripheral blood supply and vascular disorders (1).

In addition, the simultaneous application of both thermometry and thermography may ensure disease assessment even in the case of equipment breakdown for patients who are frequently traveling long distances. However, one notable significant disadvantage is the marked initial expenses of system acquisition.

Case report

A female stonecutter, who was born in 1947, worked for 4–5 hours daily until 1990 using vibrating working tools (air-pressure conducted chisels). In a cold provocation test involving a 2-min exposure to cold water at 12°C that was carried out in November 1990 during a 25-min test, no rewarming of the fingertips was discernible (Fig. 2a). Between 1990 and 1993, she was forced to decrease her working hours significantly. In a follow-up cold provocation test in 1993, a rewarming in the fingertips could be observed (Fig. 2b). In 1993, her condition forced her to give up her occupation completely. In a follow-up cold provocation test in February 1995, no blood circulation disturbances were detectable (Fig. 2c).

This case report demonstrates that the disease course in patients suffering from VWF can be evaluated by the cold provocation test with both thermometry and thermography. In our patient, the reversibility of the vibration-induced disorder was shown very clearly using both test methods. In 45% of the patients with VWF, the disorder was reversible within 7 years (2). In Germany, the approved degree of the decrease in MdE is downgraded as disease symptoms improve with time; therefore, insured individuals suffering from VWF are regularly reassessed every 1–3 years. In the context of such follow-up examinations, a standardized cold provocation test is of central importance with respect to the evaluation of the course of the disease.

Conclusions and future implications

The cold provocation test is helpful in the diagnosis of VWF and also in the assessment of VWF reversibility in patients who have stopped working in occupations involving exposure to hand-arm vibration and can, in our opinion, contribute to the standardization of vascular assessment methods.

Currently, there is a lack of data that confirm the diagnostic value of this test. However, the Institute of Occupational, Social and Environmental Medicine in Mainz is currently statistically evaluating patient data on the sensitivity, specificity, and positive and negative predictive values of thermometric

and infrared thermographic analyses performed in the context of the cold provocation test. Thermometric and infrared thermographic data from large groups of subjects are currently in preparation. Most interesting results from the comparison of patient symptoms reported in their medical histories with

thermographic and/or thermometric data and pallesthesiometric evaluation data are currently awaited. Further investigations on patients suffering from VWF is required to validate the use of the cold provocation test in obtaining sufficient data for determining the satisfactory diagnostic value of this test.

Fig. 2 Skin temperature courses for five fingertips of right hand after cold provocation test conducted at 2.5 and 2 years (proof of reversibility).

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