

Digital blood pressure after local cooling as a diagnostic tool in traumatic vasospastic disease

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ABSTRACT Measurement of digital blood pressure before and after local cooling was performed in 10 men with traumatic vasospastic disease (TVD), 10 men who worked with vibrating tools but had no symptoms in arms or hands, and 10 men who had never worked with vibrating tools. The reduction in finger systolic pressure was significantly larger in the group with TVD than in either of the two reference groups ($p < 0.001$). There was no difference between the two reference groups. Nine of the 10 patients with TVD had a larger reduction in their finger systolic pressure after local cooling than anyone in either control group. The effects of two different room temperatures (17°C and 23°C) were evaluated. At the higher temperature the overlap between patients with TVD and controls was greater. The method described seems a feasible way to obtain an objective verification of TVD.

Traumatic vasospastic disease (TVD)—that is, cold-induced blanching of the fingers after working with vibrating tools—is a common occupational disease in certain groups of workers. The history of the attacks is characteristic, but to base the diagnosis on the history alone is not satisfactory in a disease that, in many countries, may entitle the patient to workman's compensation. Since the attacks are induced by cold, cold provocation tests of different types may help in evaluating the disease.

Recently a new method for clinical investigation of vasospastic disease has been introduced—measurement of digital systolic blood pressure after local cooling.¹⁻⁴ The present study has been done to evaluate further this method of diagnosing traumatic vasospastic disease.

Subjects and methods

Altogether 30 men were examined. The first group consisted of 10 male patients referred to the clinic of occupational medicine because of a history of traumatic vasospastic disease. All described frequent attacks of typical Raynaud's phenomenon. They were car body workers, grinders, or drillers—occupations where TVD is common. Two reference groups were examined. Ten men from the same occupational groups as the patients with TVD, with

at least three years' exposure to vibrating tools but without complaints in arms or hands, comprised the exposed group, while 10 men who had never worked with vibrating tools (hospital staff) were included in the study as an unexposed reference group. Except for TVD in the patient group all the subjects were healthy, and none of them took any drugs.

Measurement of digital blood pressure was made with a technique according to Nielsen and Lassen.² An occluding cuff, placed around the base of the finger, is rapidly inflated to suprasystolic pressure. The pressure is then slowly reduced until arterial inflow reappears indicating finger systolic pressure (FSP). Distal to the cuff, arterial inflow results in an increase in volume that is measured with a dual-channel strain gauge plethysmograph (Medimatic SP 2) connected to a digital cooling system (Medimatic AS). With this device simultaneous measurements may be made in two fingers. In one finger (reference finger) the cuff is inflated by air and in the other (cooled finger) the cuff is inflated by circulating water at a preset temperature.

The subjects were examined in a room where the temperature was controlled at about 17°C by cold air circulated by a fan. They were lightly dressed and rested in the supine position for 30 minutes while the history was taken. Then the water-perfused cuff was placed around the proximal phalanx of the ring finger and the air-filled cuff around the index finger of the same hand. In the patients with TVD the hand

with most symptoms according to the case history was examined. In almost all these patients this was the left hand (all subjects were right handed). In the two reference groups the left hand was examined. The finger tips were emptied of venous blood by slight external pressure. The pressure in both cuffs was raised to suprasystolic level (~200 mmHg) for five minutes. During this period the water cuff was perfused with water at a temperature of 30°C. After five minutes the pressure was measured simultaneously in the two fingers. The test was then repeated with water at 15°C and 10°C respectively. Arm blood pressure (cuff method) and heart rate were measured before and after the test. Skin temperature was registered on the index and ring fingers of the examined hand (Ellab SD 3).

A separate study was made to evaluate the possible influence of room temperature on the test. Ten patients with a pronounced decrease in their finger systolic pressure after local cooling in a room with a temperature of 17°C and the 10 men in the unexposed reference group were examined in the same way at a room temperature of about 23°C.

FSP in the cooled finger at 15°C and 10°C was expressed in percentage of the control pressure at 30°C and was corrected for changes in the systemic pressure as measured with the air cuff according to the following formulas³:

$$FSP\%_{15^\circ C} = (100 \times FSP_{15^\circ C}) / ((FSP_{30^\circ C}) - (FSP_{ref\ 30^\circ C} - FSP_{ref\ 15^\circ C}))$$

$$FSP\%_{10^\circ C} = (100 \times FSP_{10^\circ C}) / ((FSP_{30^\circ C}) - (FSP_{ref\ 30^\circ C} - FSP_{ref\ 10^\circ C}))$$

The table explains the abbreviations.

A non-parametric test was used to evaluate the results (Willcoxon-Mann-Witney's rank correlation test).

Results

Nine of the 10 patients with TVD had a decrease in their finger systolic pressure after cooling to 10°C, exceeding that registered for any of the controls in the two reference groups. One person with a typical history of TVD had a reaction similar to that of the controls. Six of 10 patients with TVD had complete closure of their finger arteries after local cooling—that is, no blood pressure could be measured after cooling. None of the controls reacted this way (fig 1).

Both FSP%_{15°C} and FSP%_{10°C} were significantly lower in the group with TVD than in the two reference groups (p < 0.001). There was no significant difference between the two reference groups in this regard (fig 2).

Abbreviations used in the text

Temperature in water-perfused cuff	Digital blood pressure (reference finger)	Digital blood pressure (cooled finger)
30°C	FSP _{ref 30°C}	FSP _{30°C} (Control pressure)
15°C	FSP _{ref 15°C}	FSP _{15°C}
10°C	FSP _{ref 10°C}	FSP _{10°C}

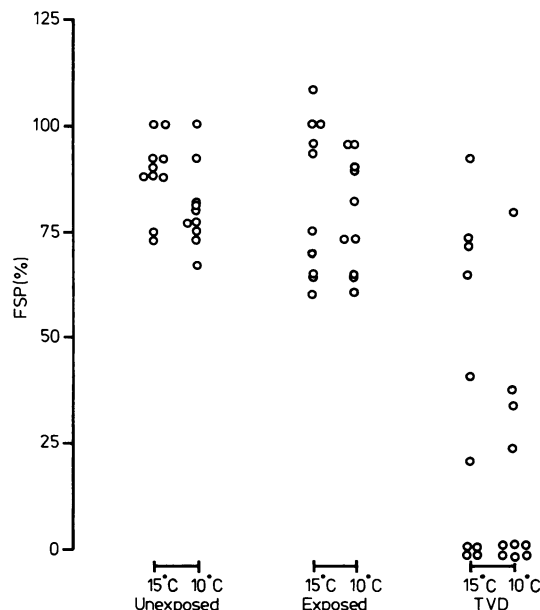


Fig 1 Finger systolic pressure in percentage of pressure at 30°C, corrected for changes in systemic pressure, in the three groups at 15°C and 10°C respectively.

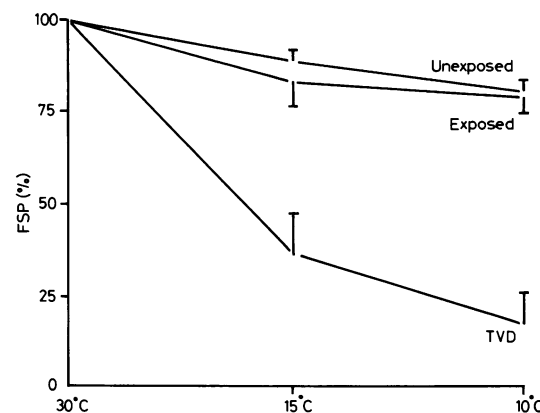


Fig 2 Change in mean FSP% in the three groups during cooling. One SE is shown.

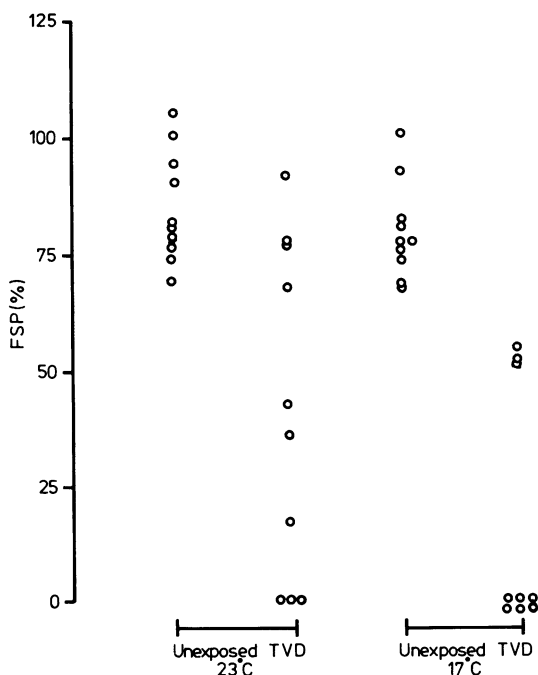


Fig 3 Lowest value of FSP% at 15°C or 10°C in unexposed control subjects and patients with TVD in a room temperature of 23°C and of 17°C.

There was no difference among the three groups in finger temperature before, during, or after the pressure readings, but the individual variations in finger temperature were great (range 18.2–26.9°C). The pressure reaction on cooling, however, could not be explained by variation in finger temperature.

In the exposed reference group there was no co-variation between FSP% and duration of exposure to vibrating tools. Nor was any co-variation between FSP% and age, systolic systemic pressure, or smoking habits observed.

Of the 10 patients included in the separate study because of a pronounced reduction of finger systolic pressure on local cooling at a temperature of 17°C, four had a reaction similar to that of the control subjects at normal room temperature (fig 3). The differences in FSP% between the patient group and the reference group in the warmer room, however, was still significant ($p < 0.01$).

Discussion

Objective verification of the symptoms of TVD is often difficult. Attempts to provoke a Raynaud's phenomenon are inconvenient because elaborate and time-consuming procedures are needed in the form of local and general cooling. Several methods

have been used to verify case histories without actually provoking an attack of white finger,^{5–7} but none is universally accepted. Many people working with vibrating tools, even if they do not have Raynaud's phenomenon or other complaints in arms or hands, seem to get a strong vasospastic reaction in their fingers when exposed to local or general cooling.⁸ Consequently, cold provocation tests, even if they distinguish between patients with TVD having clinical disease and healthy subjects not working with vibrating tools, do not necessarily distinguish effectively between patients with TVD and healthy subjects working with vibrating tools.

Measurement of finger systolic pressure after local cooling seems to provide objective verification of TVD without actually provoking an attack. Only one of our patients showed blanching of the fingers during the examination, despite the fact that nine of 10 patients had a pressure reaction after combined local and general cooling exceeding that in any of the controls. Although performed only on a small group this suggested the high specificity and sensitivity of the method, confirming the results presented earlier.⁴

The overlap in pressure reaction between patients with TVD and unexposed control subjects was greater when the measurements were made at a room temperature of 23°C than 17°C. This agrees with earlier findings in patients with Raynaud's disease, where the use of a cooling blanket increased the diagnostic sensitivity of the method.³ A room where the temperature can be reduced to 17°C thus seems to make this test more reliable.

With few exceptions, the vasospastic reaction was more pronounced with water at 10°C rather than 15°C in the perfused cuff. Thus if the test should be done at only one cuff temperature, 10°C might be the temperature of choice.

Finger systolic pressure measured after local cooling has been suggested to be an estimate of vascular tone in digital arteries.¹ If so the reduced FSP after local cooling in patients with TVD might be due to high vascular tone. It is difficult to explain why the FSP after local cooling in healthy subjects working with vibrating tools does not differ from that in unexposed subjects, since it has been shown that almost everyone working with vibrating tools, irrespective of the occurrence of TVD, has increased vascular tone as measured by temperature restitution after local cooling.⁸ The patients with TVD seem to have some additional unique factor.

References

- 1 Krähenbühl B, Nielsen SL, Lassen NA. Closure of digital arteries in high vascular tone states as demonstrated by measurement

- of systolic blood pressure in the fingers. *Scand J Clin Lab Invest* 1977;**37**:71–6.
- ² Nielsen SL, Lassen NA. Measurement of digital blood pressure after local cooling. *J Appl Physiol* 1977;**43**:907–10.
- ³ Nielsen SL. Raynaud phenomena and finger systolic pressure during cooling. *Scand J Clin Lab Invest* 1978;**38**:765–70.
- ⁴ Olsen N, Nielsen SL. Diagnosis of Raynaud's phenomenon in quarrymen's traumatic vasospastic disease. *Scand J Work Environ Health* 1979;**5**:249–56.
- ⁵ Hellström B, Myhre K. A comparison of some methods of diagnosing Raynaud phenomena of occupational origin. *Br J Ind Med* 1971;**28**:272–9.
- ⁶ Lidström IM. Lokala vibrationers inverkan på övre extremiteterna. *Arbete och Hälsa* (Arbetskyddsstyrelsen Stockholm) 1974;**8**:30–7.
- ⁷ Okada A, Yamashita T, Ideda T. Screening test for Raynaud's phenomenon of occupational origin. *Am Ind Hyg Assoc J* 1972;**33**:476–82.
- ⁸ Ekenvall L, Lindblad LE. Köldprovokationstest vid utredning av traumatisk vasospastisk sjukdom. *Opuscula Medica*, 1979;**24**:41–3.