

## Unexpected vasodilation due to cold exposure assessed by synchrotron radiation micro-angiography

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### Introduction

In cutaneous tissue, cold exposure at first brings about vasoconstriction. However, it is indicated that cooling has bilateral character about reaction against cold exposure. That means, vasoconstriction followed by vasodilation. The purpose of this study is to investigate time course of vascular reaction against cold exposure using synchrotron radiation micro-angiography (SRMA), which can visualize small arteries down to 50  $\mu\text{m}$  in diameter.

### Methods

#### *Method of cooling*

Cold exposure was induced applying vapocoolant spray to the rat left hind limb for five seconds from a distance of 15 cm.

#### *Measurement of tissue temperature*

Tissue temperature was measured by a needle type thermometer (model PTN-800, Unique Medical) and digitally recorded using PowerLabTM (ADInstruments).

#### *Imaging system*

Synchrotron radiation was obtained from a 6.5 GeV electron beam, which was converted to monochromatic X-rays by reflecting at 13 degrees off a silicon crystal. The energy of the monochromatic X-rays was 33.3 KeV, which is just above the K-edge energy of iodine. The monochromatic X-rays were converted to visible light with a fluorescent screen after passing through the hind limb. The visible light was captured by high-sensitivity CCD camera. With A-D conversion, the electrical signal was stored as a digital image in the computer system. The number of photons exceeds by  $10^5$  times conventional X-rays in per unit area. The combination of SR and the high-sensitivity CCD camera resulted in a spatial resolution of 13  $\mu\text{m}$ .

#### *Measurement of arteriole diameters*

SRMA was used for investigating the response of arterioles at the ipsilateral hind limbs to cold exposure in rats. A total amount of 3 ml of non-ionic iodine as contrast media for 5 seconds was used for angiography. SRMA was performed at pre-cold exposure (control), 30, 60, and 900 seconds after cold exposure. The diameters of arterioles were measured using computer analyzing

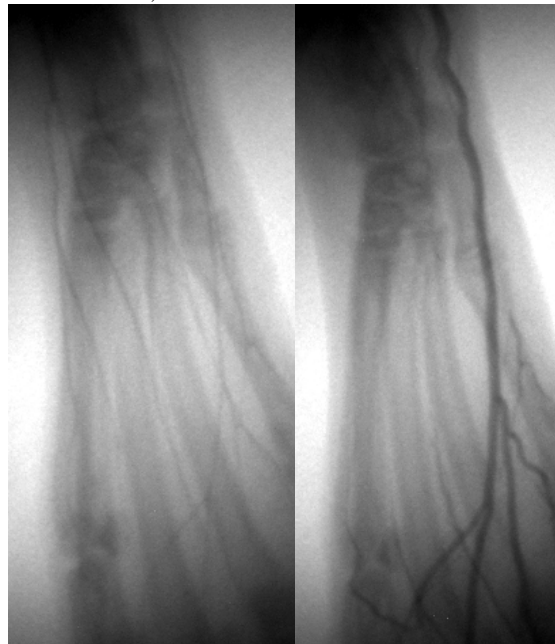
software (NIH Image). The degree of change in diameter was expressed as a percentage of the diameter at control.

### Results

(1) The minimum temperature was recorded 60 seconds after vapocoolant spray for 5 seconds (from  $33.6 \pm 0.7$  to  $19.3 \pm 2.6$  degree C). Then the tissue temperature gradually increased and recovered to the pre-exposure level after 500 seconds from initial cold exposure. (2) The maximum delta increase in diameter reached  $106.2 \pm 69.0\%$  at 60 sec after cold exposure. There was no vasoconstriction until 15 minutes after cold exposure.

### Conclusion

Deep-seated arterioles of extremities were dilated by cold exposure with vapocoolant spray without showing vasoconstriction, which was discovered for the first time.



Pre-cold exposure

60 sec after cold exposure

### References

[1] F. Sato et al., *Circ. J.* 72, 1367 (2008)

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