A new approach to simultaneously monitor (sympathetic) vasomotor reactions of skin and underlying deep tissues in man

H. Blumberg[1], S. Frisch[2], J. Husmann[2], W. Magerl[3], W. Schleinzer[2], W. Tiede[3], D. Villiger[2]

1 Dept. of Neurosurgery, Univ. of Freiburg, Germany, 2 Pain Clinic, Swiss Paraplegic Centre, Nottwil, Switzerland, 3 Inst. of Physiology and Pathophysiology, University of Mainz, Germany

INTRODUCTION

A number of painful diseases are either caused and/or accompanied by alterations in vascular supply, e.g. peripheral arterial disease (see e.g. Lang et al., 2005, Abstract 1636-P139, this meeting) and/or alterations in the sympathetic nervous system, itself or sympathetic-to-afferent coupling, which may be part of the pathology of the complex regional pain syndrome (Blumberg and Jänig 1994, Blumberg et al 1997, Wasner and Baron 2005). To differentiate the effect of vascular and/or neural systems in a painful region, methods to thoroughly assess reflex and systemic activation of vasomotor responses in affected tissue are urgently needed. This poster presents a novel method using a four channel combined laser Doppler flowmetry and near infrared spectroscopy, which allowed to simultaneously assess blood flow responses at four different sites in superficial and deep tissue (skin, muscle and bone).

References

Blumberg H, Jänig W (1994) Clinical manifestations of reflex sympathetic dystrophy and sympathetically maintained pain. In: PD Wall, R Melzack (eds.) Textbook of Pain, Churchill Livingstone, Edinburgh, pp. 685-698

Blumberg H, Hoffmann U, Mohadjer M, Scheremet R (1997) Sympathetic nervous system and pain: A clinical reappraisal. Behavioral and Brain Sciences, Vol 20, pp. 426 - 434

Wasner G, Baron R (2005) Vasomotor Changes - Pathophysiology and Measurement. In: PR Wilson, M Stanton-Hicks, RN Harden (eds.) CRPS: Current Diagnosis and Therapy, IASP Press Seattle, pp. 81 - 106

MATERIALS AND METHODS

Blood flow responses were assessed using a commercially available blood flowmeter ("O2C" oxygen to see; LEA Medical Technique, Giessen, Germany, Fig.1) in superficial and deep tissue, namely in

- hairy skin – dorsal side of thumb/ forearm
- glabrous skin – palm
- muscle – forearm flexors/extensors
- bone – distal radial and ulnar bone/proximal phalanx of thumb)

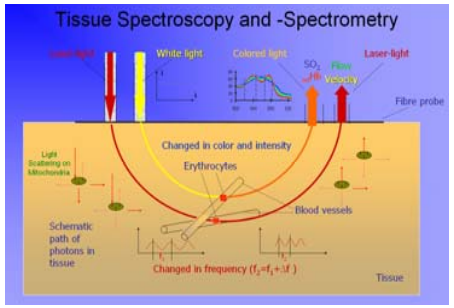
Two different principles operate to visualize blood flow at various depth of tissue:

- Laser Doppler flowmetry (LDF), a method that exploits the Doppler shift in frequency, when moving particles, like erythrocytes reflect the incident light at a shifted frequency depending on their velocity (reflecting blood flow and blood flow velocity)
- Near infrared spectroscopy (NIRS), which analyzes the spectrum of reflected white light that is backscattered from a volume of tissue (reflecting the concentration of oxygenated vs. deoxygenated haemoglobin in the tissue)

Fig. 1

The targeted depth of sampling was specified by the spacing of the sending light source and the receiving light detector (Fig.2)

Fig. 2



Four different ways of stimulations were chosen to elicit sympathetic reflexes that preferentially reflect blood flow responses mediated by outflow to the target tissue, namely deep inspiration and holding breath (apnoe), inspiration and pressing (valsalva manoeuvre), and by activation of central cardiovascular responses, resulting in an increased cardiac output, namely by forearm muscle work at 30 % of maximal voluntary contraction (handgrip) and by breathing into a closed airbag limiting the amount of available oxygen (rebreathing).

RESULTS

Manouvres manipulating sympathetic drive to the target tissue

The apnoe manouvre elicited a differential patterns of vasomotor changes in the various tissues. At the onset of stimulation, there occurred a shortlasting decrease of blood flow in all tissues under study (muscle, bone, glabrous and hairy skin), which peaked at 10-12 s and which differed in magnitude (glabrous skin > muscle ≈ bone > hairy skin). Thereafter, blood flow returned temporarily towards baseline and then decreased again, at muscle sites blood flow than increased steadily, whereas muscle sites showed a tonic de-crease till the end of stimulation. A post-stimulus reflex hyperaemia occurred in all tissues, when the stimulus was released. Clearly, this hyperaemia differed substantially in magni-tude (glabrous skin > bone > muscle > hairy skin). A similar response pattern was elicited by the valsalva test (data not shown).

Generally, the technique was feasible of a non-invasive recording of reflex responses (blood flow decreases/increases) in superficial and deep tissues (skin, muscle and bone).

Fig. 3

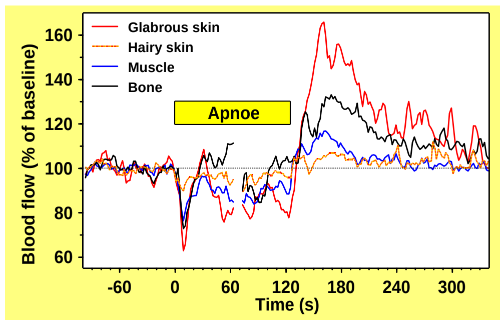


Table (Apnoe)	Early phase	Sustained phase	Post-stimulus
Glabrous skin			
Hairy skin			
Muscle			
Bone			

Manouvres manipulating cardiac output

In contrast, handgrip at 30% maximal voluntary contraction elicited a uniform pattern of reflexes in all tissues (skin, muscle, bone). Also during handgrip there was a significant initial phasic response (blood flow decrease), which peaked at 10-12 s. Thereafter, however, all recording sites showed a pronounced blood flow increase, well above baseline. After the end of stimulation, blood flow returned to baseline within a minute. Again, all reflex components were most pronounced in glabrous skin. A similar response pattern was elicited by rebreathing (data not shown).

We interpret this response pattern by a change in central sympathetic drive resulting in an increased cardiac output, hence eliciting a similar type of peripheral response.

Fig. 4

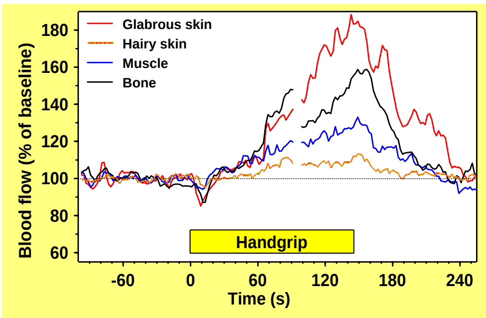


Table (Handgrip)	Early phase	Sustained phase	Post-stimulus
Glabrous skin			
Hairy skin			
Muscle			
Bone			

SUMMARY AND CONCLUSIONS

- **The combined laser Doppler and near infrared spectroscopy techniques allow the simultaneous assessment of blood flow responses in all superficial and deep tissues**
- **After initial similar flow decrease, during stimulation apnoe exhibited a differential flow response, which allowed to identify the tissues under study**
- **In contrast, the response to handgrip (flow increase) showed a uniform pattern in superficial and deep tissues, albeit different in magnitude**
- **The combination of these non-invasive techniques with specific sympathetic challenges allowed a quantitative assessment of sympathetic function in superficial and deep tissues**
- **We suggest that the technique may be a valuable novel approach to study the integrity of sympathetic reflexes: afferent stimulation, central nervous integration and sympathetic (vasomotor) influence upon blood flow regulation, which may be utilized in pain research and diagnosis**