Neurophysiological Assessments

NEUROPHYSIOLOGICAL ASSESSMENTS OF AUTONOMIC FUNCTION UNDERTAKEN BY DR PETER JULU AT THE BREAKSPEAR HOSPITAL

Methods:

- The patient is examined in a quiet laboratory with subdued light at a room temperature of approximately 24^{o}C;
- The NeuroScope™ method is a novel neuro-physiological technique for assessing brainstem autonomic functions. It measures systolic blood pressure (SBP) and diastolic blood pressure (DBP) and mean arterial blood pressure (MAP);
- The patient is attached to a small finger appliance.
- A special belt around the chest is used to monitor continuous breathing movements;
- An electrocardiogram is monitored continuously throughout the autonomic examination;
- A number of manipulations of the autonomic nervous system are then carried out, and the observed abnormalities are recorded on equipment which measures changes;
- Interpretations are based on a normal range of values obtained using standardised procedures.

Parasympathetic Function and Cardiovascular Reflex:

- The carotid sinus, which is located in the neck, is massaged. Changes in the effect of both the sympathetic "fight and flight" mechanisms and the parasympathetic "rest and digest" systems are measured. Organs in the carotid sinus influence both of these functions;
- A 10 second cycle of deep breathing increases the strength of the nerve signals that slow the heart;
- The patient is then asked to change position, and the effect of this on the heart is recorded. A variation of the mean arterial pressure of more than 25mmHg suggests orthostatic instability. A sustained fall in diastolic blood pressure by 10mmHg or more within 3 minutes of assuming an erect posture, compared with the level in a supine position, is an indication of orthostatic hypotension;
- The patient is then asked to compress a divided metal bar (isometric exercise) and changes in the ECG R-R intervals and blood pressure will result;

Diagnostic Testing:
The purpose of Autonomic Nervous System tests is to identify patterns of abnormalities using a battery of tests.

Target-organs in the Brain:
These target-organs are examined using a set of cardiovascular reflexes controlled in the brainstem. The resting cardiac vagal tone is measured using a specialised machine called the NeuroScope™ . The effects of deep breathing on cardiac vagal tone and the level of central gain (amplification) of the baroflex system are measured. These are parasympathetic functions of the brainstem.

Target-organs in Large Blood Vessels including the Heart:
These target-organs are examined using another set of cardiovascular reflexes, but either the stimuli are applied directly to the relevant receptors or specialised manoeuvres are used to optimise stimulation of the relevant receptors. Standardised manoeuvres recommended for examination of the autonomic nervous system are deployed. "Carotid massage" is used to elicit its cardioinhibitory effect and this is measured in the form of increased cardiac vagal tone, which is a direct brainstem response to

- The patient is then asked to take a deep breath and try to blow out this breath against resistance in a special apparatus. This is called the Valsalva's manoeuvre. The longest interval between R-R intervals is after the Valsalva's manoeuvre, compared with the shortest R-R interval during the manoeuvre.

A lay preview of Sympathetic Function:

- Emotional sympathetic sudomotor effects are shown by changes in skin responses in the form of sweating in the palms of the hands and soles of the feet. In order to induce this, the patient is asked to perform a single inspiratory gasp and the changes are recorded;
- Thermoregulatory vasomotor function, ie. the effects of temperature on the skin and the regulation of the calibre of special blood vessels, is assessed with a cold challenge applied to one hand, while recording the skin blood flow in the limbs on the other side, first by putting the hand into warm water for 2 minutes, then transferring the hand to cold water for another 2 minutes, thus inducing dilation and then constriction of the blood vessels. The cool hand is then put back into warm water for a further 2 minutes and the changes are measured in the blood flows in contra-lateral limbs together during the challenge and the return to baseline levels in response to re-warming.
- A special test, which involves the hands gripping an instrument, is used to measure sympathetic activity in the skeletal muscles by measuring the diastolic blood pressure levels. Heart rate is used to measure sympathetic activity in the heart and recordings are compared with pre-exercise levels;
- The gradient of the blood pressure rise during ejection of blood out of the heart tells us about the function of the heart ventricles (inotropic function);
- With the Valsalva's manoeuvre one can tell what is happening in compensation to insufficient blood returning to the heart when the intrathoracic pressure is raised. The major organs in the abdomen have to constrict in order to push the blood back into the thorax. If this is done without the legs being moved, which is a further source of blood volume, then it is specifically a measure of what is happening in the organs of the abdomen. This is called reflex "auto-transfusion".

Clinical Examination of Sympathetic Functions:

- Emotional sudomotor function (ESF) in the skin is assessed by measuring the galvanic skin responses to

mechanical stimulation of the carotid baroreceptors. The "carotid massage" is also used to elicit its vaso-depressor effect measured in the form of a decrease in systolic blood pressure, which is also a direct brainstem response to mechanical stimulation of the carotid baroreceptors. A sustained isometric exercise is used to abolish the parasympathetic negative feedback control on the cardiovascular system so that one can assess the cardioaccelerator function of the sympathetic system. In all these there is a mixture of parasympathetic and sympathetic target-organs examined separately and exclusively.

Target-organs deep inside the Body: *Special and standardised manoeuvres are used to optimise the examination of these target-organs. Sustained isometric exercise is used to abolish the parasympathetic tone so that one can assess the sympathetic tone in skeletal muscles. A controlled Valsalva's manoeuvre is also used to mechanically reduce the volume of blood returning to the heart so that an assessment of the sympathetically mediated reflex "auto-transfusion" can be initiated. This is controlled by the splanchnic nerves.*

Superficial Target-organs situated in the Skin: *The Laser Doppler blood flow meter is used to specifically elicit the thermoregulatory vasoconstrictor reflex of the sympathetic system in the skin.*

emotional (or mental) sweating in the palms of the hands and soles of the feet. The galvanic skin response is evoked by a single inspiratory gasp and measured in voltages;

- Thermoregulatory vasomotor function (TVF) in the skin is assessed using a cold challenge, which is applied to one hand while recording the skin blood flow in the contralateral limbs. The cold challenge is achieved by first immersing the hand in warm water (40^{o}C) for 2 minutes to maximise vasodilatation before transferring it into cold water (10^{o}C) for another 2 minutes to evoke a vasoconstriction. The cooled hand is then re-immersed in warm water for a further 2 minutes. The skin blood flow in the dorsum of all 4 limbs is measured simultaneously using a four-channel laser Doppler flow meter (Moor Instruments, Axminster, UK). Normal responses are indicated by decreases of blood flow in both collateral limbs during the cold challenge and a return to base-line levels in response to re-warming. Failure of TVF is indicated either by no effect of the cold challenge on skin blood flow, or a paradoxical increase of blood flow in the contralateral limbs;
- Sympathetic cardioaccelerator function in the heart and sympathetic vasoconstrictor response in the skeletal muscles are assessed during isometric exercise by measuring the change in heart rate (HR) and diastolic blood pressure (DBP) respectively, in the third minute of isometric exercise compared with the level just before the onset of the exercise;
- The gradient of BP rise in the ejection period of the cardiac cycle is used as an index of beat-to-beat left ventricular inotropic function;
- The sympathetic adrenergic function in the splanchnic vascular bed is assessed during the Valsalva's manoeuvre as follows:
    - Phase I is the initial rise in BP due to pressure on the great vessels in the thorax;
    - Phase IIe is the early sharp drop in systolic blood pressure (SBP) and pulse pressure due to the sustained reduction in venous return caused by the positive intra-thoracic pressure;
    - Phase IIi is the later recovery of both the SBP and the pulse pressure against the positive intra-thoracic pressure and is due to sympathetic mobilisation of a reserved volume of blood from the splanchnic vascular bed, stimulated by the crisis of blood volume in the heart. This is a physiological process called "auto-transfusion" (Keele et al., 1982). The inferior vena cava carries more than 2/3 of the venous return, but venous return from the lower limbs

depends largely on the muscle pump effect. Our subjects carry out the Valsalva's manoeuvre in a sitting position without moving the lower limbs while leaning forwards to exclude any contribution from vasoconstriction or the muscle-pump effect in the lower limbs to the recovery of pulse pressure and SBP, allowing us to assess the splanchnic sympathetic adrenergic function selectively.

Transcutaneous Blood Gases:

- A non-invasive probe is placed on the skin. This measures the partial pressure of oxygen and carbon dioxide in the peripheral tissues, also known as the nutritive circulation. This is not the same as the level of oxygen or carbon dioxide that is carried around by haemoglobin in the large blood vessels, but reflects the perfusion and utilisation of the gases in the tissue where cellular processes takes place. The transcutaneous gases are recorded with the person lying on their back resting, and with the person taking deep breaths.

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Transcutaneous Blood Gases: *The balance between carbon dioxide and oxygen in the soft tissues is crucial to normal functioning at a cellular level. Some people have been found to have too high levels of carbon dioxide. This contributes to a state of acidosis in the cells, and would contribute to fatigue. Some people have too low levels of carbon dioxide, which can lead to abnormal responses by the brainstem. Some people have been found to be hypoxic with very low levels of oxygen. The gases are assessed to see if the abnormalities can be corrected by deep breathing, or by other breathing techniques.*