Chapter 7.3

Assessment of blood pressure regulation

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Method

Different methods to evaluate heart rate variability, described in the preceding chapter, are generally considered to adequately reflect vagal/parasympathetic control of the heart whereas the ability of these methods to monitor sympathetic function is limited. Evaluation of autonomic reflex function in a clinical neurophysiology laboratory therefore usually includes an orthostatic test, where a stable blood pressure in upright position critically depends on sympathetically mediated peripheral vasoconstriction. Heart rate changes during orthostatic tests may, on the other hand, be vagally and/or sympathetically mediated.

Blood pressure measurement during orthostatic challenge may be carried out with sphygmomanometric measurements (manual or automatic) on the upper arm or continuous perfusion controlled volume-clamp measurement (Penz-technique, Finapres, Portapres).

Both methods have their advantages and disadvantages, but for routine use automatic sphygmomanometric measurements are strongly recommended (cf. below). The orthostatic provocation can be ‘passive’ (i.e. performed on a tilt table) or active (subject rising from a supine position). Blood pressure responses to a number of other stimuli (i.e. Valsalva, mental stress, isometric exercise) may also be investigated.

Indications

In clinical practice, two general situations initiate testing of autonomic cardiovascular function: (1) patients reporting symptoms of orthostatic hypotension, such as dizziness, light-headedness, (pre-)syncope, fatigue, neckache; (2) clinical suspicion of autonomic failure in association with central degenerative diseases (i.e. Parkinson’s disease, multiple system atrophy), peripheral polyneuropathies (i.e. diabetes, Guillain–Barré) or high spinal cord lesions. It is important to stress that cardiovascular autonomic failure is asymptomatic in many patients and can be atypical in clinical presentation. Hence, objectively establishing autonomic failure in a laboratory test can contribute considerably to differential diagnosis and pathophysiological understanding. It should, however, also be underlined that the autonomic nervous system is highly differentiated, sending different messages to different effector organs, and results from one
Physiological background

The principle task of the cardiovascular system is to supply all cells of the organism with necessary substances and to dispose of and distribute metabolic products. This must be guaranteed under all sorts of conditions and circumstances. For that purpose perfusion of all organs must be maintained as constant as possible. As it is technically difficult and invasive to measure perfusion in single organs in vivo in man, blood pressure represents an easily measured general parameter of the cardiovascular system. Blood pressure is determined by heart rate, resistance of peripheral arterial vessels and cardiac ejection volume. These 3 parameters are regulated and adjusted by efferent neuronal activity of the central autonomic nervous system, if the observed value is changed by external perturbation or if the setpoint changes. In addition, these parameters are influenced by organ specific neuronal and humoral reflex systems.

The baroreflex is the fastest and most important mechanism for dynamic blood pressure regulation. It is organized as a neural negative-feedback system that lowers high pressure values and increases low values. Pressure-sensitive receptors in the carotid sinus and aortic arch, with afferent fibres travelling in the glossopharyngeal and vagal nerves, are activated by stretching of the vessel walls during blood pressure increases. Baroreceptor afferent activity, relayed and integrated in central medullary autonomic nuclei such as the nucleus tractus solitarius, increases vagal and inhibits sympathetic discharge to the heart, and inhibits vasoconstrictor discharge to resistance vessels.

Long-term regulation of blood pressure is predominantly controlled by neurohumoral factors and systems like atrial natriuretic peptide, the renin-angiotensin system and the hypothalamo-pituitary-adrenal axis. The role of the sympathetic nervous system in the control of long-term blood pressure level is unclear.

Technical requirements

The following equipment is necessary for standardized orthostatic tests:

- Room with minimum $3 \times 5 \text{ m}$, noise-isolated and temperature-controlled
- Sphygmomanometric blood pressure measurement device, preferably automatic
- Perfusion-controlled volume-clamp blood pressure monitoring device (Penaz-technique, Finapres, Portapres): optional
- Electrocardiograph: optional, rate can be triggered from the blood pressure curve
- Plotter and/or digital data acquisition equipment
- Tilt table
- Stopwatch

Clinical protocols for the investigation

Preparation for testing

- Patients should empty their bladder before testing
- Allow for adaptation of the patient to the laboratory
- Place patient comfortably on tilt table. Ensure that soles have firm contact with foot board, in order to stand securely during tilting. Consider securing patient with bands around knees and abdomen if syncope during tilting is anticipated
- Mount measurement equipment
- Set automatic sphygmomanometry device to shortest possible measurement interval
- If non-invasive monitoring technique is used, control position of arm with finger cuff at heart level using special arm rest or triangle cloth
- Avoid any disturbances from outside during the initial rest period of 10 min

Tilt table test

- Inform patient about the manoeuvre and ask him to report symptoms in upright position. Be careful of cables when patient is tilted
- Ensure a preceding rest period of at least 1 min with artefact-free recording of parameters
- Inform patient about beginning of manoeuvre.
- Tilt patient to 70° upright position, mark beginning and reaching of 70° position on the recording
- If used, check proper position of the arm with Finapres device at heart level and relaxation of fingers
- Continue upright position over minimum of 3 min up to 8 min if orthostatic hypotension is suspected, over 25 min if vasovagal syncope is suspected, or until patient reports imminent syncope
- Use servo self-adjustment of blood pressure recording after 90 s (only when using Finapres device)
- Return patient to supine position, mark beginning and reaching of supine position on the recording
- Repeat manoeuvre in case of technical artefacts, for example indicated by the servo self-adjustment

**Factors affecting the quality of the investigation**

**Patient-dependent factors**

*Physical and cognitive ability for cooperation.* Inability of patient to perform challenge procedure adequately or to relax sufficiently influences results. In central degenerative disease, tremor can present a major artefact problem.

*Age.* Blood pressure increases during tilt table test and standing up decrease with age.

*Sex.* There are conflicting data on the influence of sex on cardiovascular regulation, but gender does not significantly affect normal limits for blood pressure change during orthostatic tests.

*Physical condition.* Physical training has no impact on blood pressure values during orthostatic stress.

**Metabolic factors**

*Glucose.* In healthy subjects food ingestion has no influence on blood pressure values. In patients with autonomic failure blood pressure is lowered under resting and orthostatic conditions, predominantly related to the amount of carbohydrate intake. Post-prandial hypotension reaches its nadir within 60 min.

*Caffeine.* Occasional consumption of caffeine acutely increases blood pressure in supine position. Blood pressure values during challenge procedures are not influenced in healthy subjects.

*Alcohol.* Occasional and regular alcohol consumption increases resting blood pressure. In healthy subjects there is no influence on blood pressure values during orthostatic stress, while blood pressure decreases in patients with autonomic failure.
Nicotine. Nicotine induces increases in blood pressure during rest and challenge procedures.

Methodological factors

Preceding period of rest. A positive relation between preceding period of rest and initial fall of blood pressure after change of posture has been reported.

Filling of bladder. Degree of bladder filling has a variable influence on cardiovascular responses. Therefore, emptying of the bladder before testing is recommended.

Mode and speed of change in posture and period in upright position. In healthy subjects cardiovascular adaptation to change in posture is completed within an upper limit of normal of 38 s, independent of the mode. Mean blood pressure values after 60 and 90 s upright position do not differ between tilt table tests with varying tilt speed and active standing. Thus, 3 min in an upright position may be sufficient to detect orthostatic hypotension of neurogenic or non-neurogenic origin. Testing periods of up to 40 min have been reported as necessary to achieve sufficient sensitivity for the investigation of vaso-vagal syncope.

Degree of upright position during tilt table test. Blood pressure responses show no relevant differences between 60° and 80° upright position. 90° upright is uncomfortable for the subject.

Room temperature. Room temperature influences capillary peripheral resistance. Therefore, auto-

![Blood pressure graphs](image1)

Fig. 1. Blood pressure during active standing in a normal subject (upper) and a patient with autonomic failure (lower). Vertical bars indicate start and end of change of posture. Horizontal bar indicates period in upright position. Calibration controls for correct measurement while upright.
nomic function tests should be performed under constant conditions with a neutral temperature of, for example, 23°C.

Time of day. Time of day has no influence on blood pressure regulation in healthy subjects. In patients with autonomic failure, blood pressure values during challenge procedures are usually lower before 2:00 p.m. in comparison with results obtained in the afternoon or evening. This is caused by loss of intravascular volume during the night and inverse circadian rhythm in these patients.

Hydrostatic artefacts. If non-invasive blood pressure monitoring is considered, it should be stressed that the Finapres device is seriously limited by its sensitivity to hydrostatic artefacts, even if meticulous care is taken to secure the recorded finger at cardiac level. Thus, Finapres values should always be referenced to sphygmomanometric values. The advantage of adding a Finapres recording is that rapid blood pressure changes, often missed by the slower sphygmomanometry, can be picked up.

How to report results

Blood pressure is analysed during rest and at defined points during orthostatic challenge (Figs. 1 and 2). Differences to baseline of blood pressure are often used for the assessment, because they are independent of baseline values over a wide range of resting blood pressure values and therefore have smaller interindividuale variation than absolute values. There is no general consensus on which points in time have to be reported but many laboratories calculate baseline systolic and diastolic blood pressure values from a 60 s rest period, and relate these to pressure levels recorded after 30, 60 and 90 s upright position. There are no generally accepted normal values for standard autonomic function tests. Due to differences in techniques of measuring blood pressure and protocols used, each laboratory should obtain its own normal data. However, the term 'orthostatic hypotension' has been defined as a fall of systolic or diastolic blood pressure of 20 mmHg or more within a period of 3 min in an upright position. It represents a measurement-technical term, which is independent of the presence of clinical symptoms (Anon., 1996).

References to recent reports on normal data from several laboratories are given below (Piha, 1991; Braune et al., 1996; Karemaker, 1997; Low et al., 1997).

If baseline supine blood pressure values are outside normal limits, cardiovascular or endocrine disease, volume depletion or effects of medication must be considered before an underlying autonomic dysfunction is assumed.

References


