The accurate measurement of blood pressure (BP) is an important diagnostic and monitoring tool in a wide range of clinical conditions. Good practice is essential when measuring BP to ensure abnormalities are identified and patients receive the correct treatment and care in a timely manner. This article reviews the principles guiding the non-invasive measurement of BP. Part 2 of the series will explain the different procedures for measuring BP.

General principles of measurement
Terms used in the measurement of BP are outlined in Box 1.

- Manually, using the auscultatory method – this involves listening to arterial sounds (named ‘Korotkoff sounds’, after Nicolai Korotkoff, a Russian surgeon who first described the auscultation method of measuring BP in 1905);
- Automatically, using the oscillometric method – this detects variations in pressure oscillations due to arterial wall movement.

Both methods use a measuring device attached to an inflatable cuff that is placed around the patient’s upper arm, inflated to occlude the artery under the cuff, then released in a controlled manner.

BP is a variable haemodynamic phenomenon, and can be influenced by a range of factors; these are outlined in Box 2. In some situations, for example when managing a patient with hypertension, it is advised to undertake three consecutive BP readings to improve accuracy. Posters and videos outlining how to measure BP can be downloaded from: Bit.ly/BIHSBPMeasurement.

Arm selection and patient position
BP should initially be measured in both arms, after which the arm with the higher reading(s) should be used for subsequent measurements (O’Brien, 2015). Although a difference in BP measurements between the arms can be expected in 20% of patients, if this difference is >20mmHg for systolic or >10mmHg for diastolic measurement, BP should be measured on both arms for the next reading. If these differences are seen in three consecutive readings (with a one-minute gap between each), further investigation may be indicated (O’Brien, 2015).

The patient’s arm should be supported while BP is measured; if it is unsupported muscle contraction in the arm can lead to...
an erroneous increase in the BP reading by as much as 10% (O’Brien, 2015).

The arm should be positioned at heart level: if it is lower than the heart, this can lead to overestimation, while being above the level of the heart can lead to an underestimation. This error may be as great as 10mmHg (O’Brien, 2015). If seated, the patient should not cross their legs as this can lead to an increase in BP.

Cuff size
It is vital that the appropriate cuff size is used when measuring BP. Miscuffing – particularly using a cuff that is too small – can lead to inaccurate readings (O’Brien, 2015); if a cuff is too small, the BP will be underestimated and, if it is too big, the BP will be overestimated. In general, there are three cuff sizes:

- Children or small adults;
- Standard adults;
- Obese adults.

The inflatable bladder should encircle between 80% and 100% of the arm.

Manual auscultatory measurement
Manual BP measurement devices require the user to inflate the upper-arm cuff to occlude the brachial artery, then listen to the Korotkoff sounds through a stethoscope while the cuff is slowly deflated. When the cuff is slowly deflated, five different sound phases can be heard:

- Phase I – a thud;
- Phase II – a blowing or swishing noise;
- Auscultatory gap – in some patients, the sounds disappear for a short period;
- Phase IV – a softer thud than in phase I;
- Phase V – silence: all sounds disappear (O’Brien, 2015).

Practically, the systolic reading is when the Korotkoff sounds are first heard and the diastolic reading is when they disappear.

The patient’s systolic (phase I) and diastolic (phase V) BP are recorded from the sphygmomanometer. Although portable and generally reliable, manual BP devices require clinical skill and are prone to observer bias (Medicines and Healthcare products Regulatory Agency, 2019). Mercury sphygmomanometers are considered the ‘gold standard’ in BP measurement but, as mercury is a toxic substance, there are maintenance and disposal problems and environmental concerns. As a result, these devices are being phased out: their use has already been banned in some European countries, while in the UK a ban on their sale will be introduced from 31 December 2020 (MHRA, 2019). It would, therefore, be prudent for healthcare providers still using mercury sphygmomanometers to start planning to phase these out and to ensure health professionals are competent at using alternative devices.

Devices that are generally used for manual BP measurement include:

- Aneroid sphygmomanometer – this replaces the mercury manometer with an aneroid (liquid-free) gauge that registers pressure using a bellows and lever system (O’Brien, 2015), and
- Electronic sphygmomanometer – this battery-powered device replaces the mercury manometer with a pressure sensor and electronic display. The display may be numerical, or a circular or linear bar graph. No stethoscope is needed.

Where local protocols dictate that mercury devices still need to be used, Control of Substances Hazardous to Health (COSHH) and health and safety procedures and regulations should be followed (MHRA, 2019). Health professionals should be trained in:

- Site handling during normal use;
- Storage of the device;
- What to do in the event of a mercury spillage (mercury spillage kits should be available);
- What procedures to follow in the event of mercury disposal or when the device is discarded (MHRA, 2019).

Although aneroid sphygmomanometers are mercury free and easy to use, wear and tear or mechanical shock to the mechanism can lead to incorrect readings; this means regular calibration checks are required. Electronic sphygmomanometers are prone to observer bias and require clinical skill to use accurately (MHRA, 2019). Devices need regular maintenance in line with the manufacturer’s instructions and local policy.

### Automated measurement

**Automated electronic BP devices**

Most automated BP measurement devices in current clinical practice use the oscillometric method. Each arterial pulse wave results in a small rise and fall in the volume of the limb which, in turn, causes an increase then a decrease in the pressure within the encircling cuff (Lewis, 2019). The oscillometric method relies on detection of variations in pressure oscillations due to arterial wall movement beneath an occluding cuff to calculate the systolic and diastolic BP readings (Lewis, 2019).

It is important to note that some automated oscillometric BP measurement devices are unreliable in patients with cardiac arrhythmia, such as atrial fibrillation (AF) (National Institute for Health and Care Excellence, 2019); this is because the pulse pressures can vary significantly with each pulse. Where possible, manual BP measurement should be used when a patient has AF (Clark et al, 2019).

Extreme bradycardias can also cause inaccurate BP readings (O’Brien, 2015); again, where possible, manual BP measurement is preferable, with slow cuff deflation.

A number of automated BP measurement devices are available including:
Postural hypotension

Postural hypotension, sometimes termed orthostatic hypotension, is when an abnormally low BP occurs when a person suddenly assumes a standing position, typically inducing dizziness and syncope. The condition is more common in older people and its prevalence increases with age. It can also be caused by a number of medications including diuretics and anti-hypertensive therapy (Windsor et al, 2016). Postural hypotension can present with a clinical picture of dizziness, syncope and falls on changing position. Although it may seem to be a relatively harmless phenomenon, the patient’s safety and quality of life can be seriously affected.

Falls risk assessment

Measurement of lying and standing BP is part of a multifactorial patient risk assessment (Royal College of Physicians, 2017). A diagnosis of postural hypotension is indicated when there is a:

- Drop in systolic BP of ≥20mmHg (with or without symptoms);
- Drop in BP to <90mmHg on standing, even if the drop is <20mmHg (with or without symptoms);
- Drop in diastolic BP of 10mmHg with symptoms (but, clinically, much less significant than a drop in systolic BP).

NICE (2013) stated that the following groups of patients should be considered as at risk of falling in hospital and receive an individualised, multifactorial assessment, including lying and standing BP:

- All patients aged ≥65 years;
- Patients aged 50-64 years who are judged by a clinician to be at higher risk of a fall due to an underlying condition.

Errors in measurement

There are numerous causes of errors in BP measurements, including:

- Patient not being rested and relaxed when BP is measured;
- Defective equipment – for example, leaky tubing or a faulty valve;
- Too-rapid deflation of the cuff;
- Use of incorrectly sized cuff;
- Cuff not being on a level with the heart;
- Poor technique;
- ‘Digit preference’ – rounding a reading up to the nearest 5mmHg or 10mmHg;
- Observer bias – for example, expecting a young patient’s BP to be normal;
- Irregular pulse (as can occur with, for example, AF, bradycardia, muscle tremors, a weak pulse or profound shock) – in some automated devices, this can lead to inaccurate measurement (MHRA, 2019, O’Brien, 2015).

Checking and maintenance

All BP measuring equipment should be regularly checked and calibrated in accordance with the manufacturer’s instructions (MHRA, 2019). Cuffs and their hoses should be regularly inspected and replaced as necessary; excessive air leakage from damaged cuffs, hoses and tubing connectors may reduce the accuracy of the readings. If reusable cuffs are used, they should be cleaned between patients in accordance with the manufacturer’s instructions, ensuring that cleaning fluid does not enter the cuff bladder or hoses.

Faulty devices can lead to inaccurate BP measurements, with significant effects on patient care. Healthcare providers have a responsibility to ensure adequate maintenance arrangements are in place (MHRA, 2019).

Aneroid devices are particularly prone to inaccuracies (Coleman et al, 2005); the MHRA (2019) recommends these are checked and calibrated at least twice a year. Hand-held devices used in the community are particularly prone to shocks and drops, but devices that incorporate anti-shock mechanisms may be more resilient to this type of wear and tear.

It is considered good practice to occasionally check the device against another validated device (BIHS, 2017).

Conclusion

Accurate measurement of BP is an important diagnostic and monitoring tool in a wide range of clinical conditions. Nurses must be able to carry out the procedure accurately and reliably, and should be aware of the common pitfalls that can lead to inaccuracies. Part 2 of this series will explain the procedure for measuring BP. NT

References

Royal College of Physicians (2017) Measurement of Lying and Standing Blood Pressure as Part of a Multifactorial Falls Risk Assessment. RCP.