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A guide to undertaking and understanding blood pressure measurement

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A guide to undertaking and understanding blood pressure measurement

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Abstract

This article will:

- Provide background information on blood pressure
- Outline the autonomy and physiology associated with the skill of blood pressure measurement
- Outline the varying techniques for taking blood pressure measurement, both invasively and non-invasively
- Explains the procedural steps for taking a manual blood pressure
- •Provides top tips for carrying a manual blood pressure
- Introduce the readers to some of the additional risks associated with patients who are undergoing surgery and taking oral anticoagulants.
- Explore the use of vitamin K antagonists and heparin
- Discuss some of the management strategies and additional considerations that need to be addressed during the perioperative care continuum.

A guide to undertaking and understanding blood pressure measurement

What is blood pressure?

Blood pressure (BP) measurement is widely recognised as being a routine observation that can be used as a way to assess cardiac output and its effectiveness for adequate tissue perfusion (Odell, 2013). Thus, the presence of a BP is a requirement for human existence (Beevers and Lip, 2015), and BP measurement, which includes interpreting results and taking appropriate action, is considered a key clinical skill to acquire and maintain as results can determine patient care (Lister et al., 2021).

Anatomy and Physiology

A BP measurement, in its simplest form, is a determinant of individual cardiac output (the volume of blood pumped out of the heart and into the aorta per minute) and the systematic vascular resistance (the diameter of the arterial blood vessels) (Foley, 2015). To fully understand this process, it is essential that healthcare professionals possess the underpinning knowledge of the anatomy and physiology associated with the cardiovascular system ***(see image 1).*** The cardiovascular system includes the heart**,** arteries, veins and capillaries and its main function is to distribute blood throughout the body, ensuring water, nutrients, chemicals, and waste products are exchanged to and from bodily tissues (Boore, Cook and Shepherd, 2016; Nair, 2017).

Heart

The heart is the main organ responsible for pumping blood throughout the body. It is the size of a fist, situated in the thoracic cavity, in the mediastinum behind and left of the sternum, and as such, well-protected (Boore, Cook and Shepherd, 2016; Clare, 2017). The organ itself is primarily constructed from muscle tissue and is separated

and divided into four chambers by thin walls of tissue and valves to prevent back flow and maintain the efficiency of the heart muscle pump (Boore, Cook and Shepherd, 2016). In the simplest terms, it is best to think of the heart as two pumps (left and the right) each with an upper and lower chamber with the superior being the right and left atria and the inferior the right and left ventricles (Clare, 2017). The atria are smaller than the ventricles and are divided by the interatrial septum and the larger ventricles are separated by the interventricular septum.

The right pump receives deoxygenated blood from the veins and sends it to the lungs; whereas the left side receives freshly oxygenated blood from the lungs and then distributes it around the rest of the body (***see image 2*** for a detailed image showing the movement of blood through the heart). Whilst the same amount of blood is pumped by the dual pumps (right and left) the distance this blood needs to travel is vastly different; consequently, the right ventricle wall is thinner, as reduced muscle strength is required due to the shorter distance and reduced pressures found within the pulmonary circulation and the left ventricle has a thicker muscle wall due to the additional force needed to send blood around the body (Boore, Cook and Shepherd, 2016; Clare, 2017).

This muscle wall has specialised cells that create and conduct impulses throughout the heart to ensure blood flow is consistent and adequate for the body's requirements (Peate and Jones, 2022). The main components of this are the sino-atrial node, the atrio-ventricular node, the bundle of His, the right and left bundle branches and the Purkinje fibres ***(see image 3).***

Image 1: The cardiovascular system (BJN to insert image–see example below)

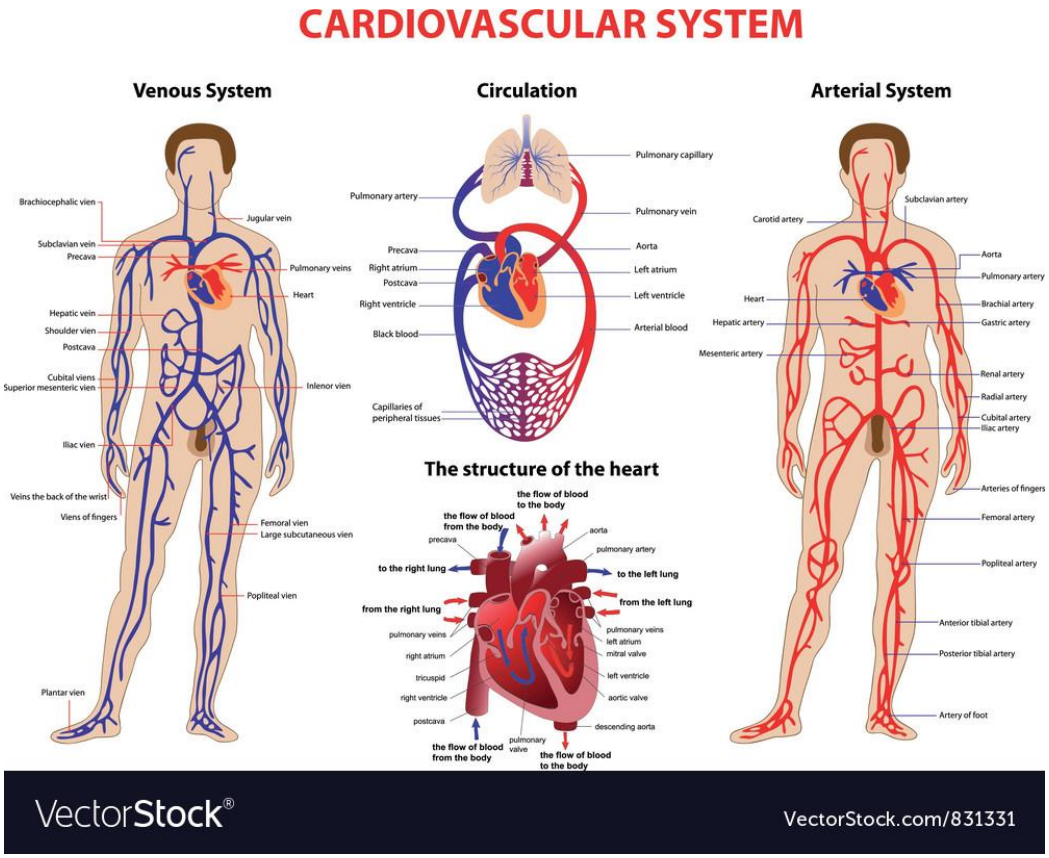
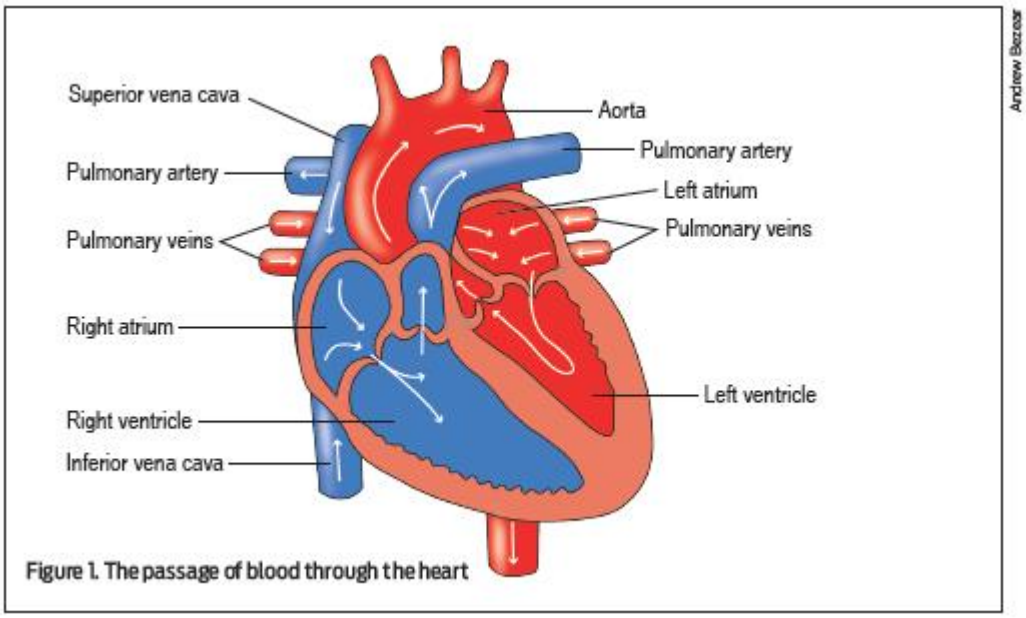
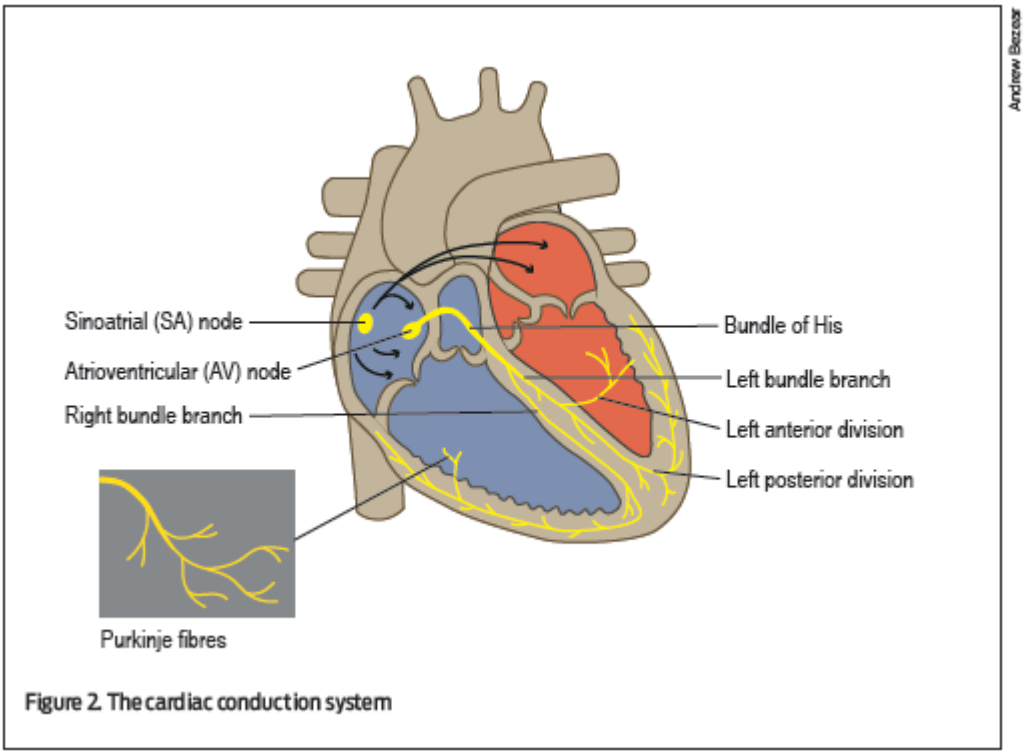


Image 2: flowchart showing the movement of blood through the heart



(Peate and Jones, 2022)

Image 3: Cardiac conduction system



(Peate and Jones, 2022)

Arteries, Veins and Capillaries

Vessels that carry blood away from the heart are referred to as arteries that branch out into smaller arterioles. The vessels that return blood to the heart are known as veins which also branch into smaller vessels, these are known as venules (Waugh and Grant 2018). Venules and arterioles then connect to the capillary network, and this is where the exchange of nutrients, gases and waste products takes place at a cellular level (Nair, 2017). As all three main types of vessels perform varying functions their anatomical structure and size are diverse in order to ensure maximum efficiency (***see image 4***). As arteries carry blood away from the heart under higher pressure, they, therefore, have thicker walls and smaller lumen (***see image 5***), to maintain high pressure, whereas veins are constructed with larger lumen to accommodate a larger

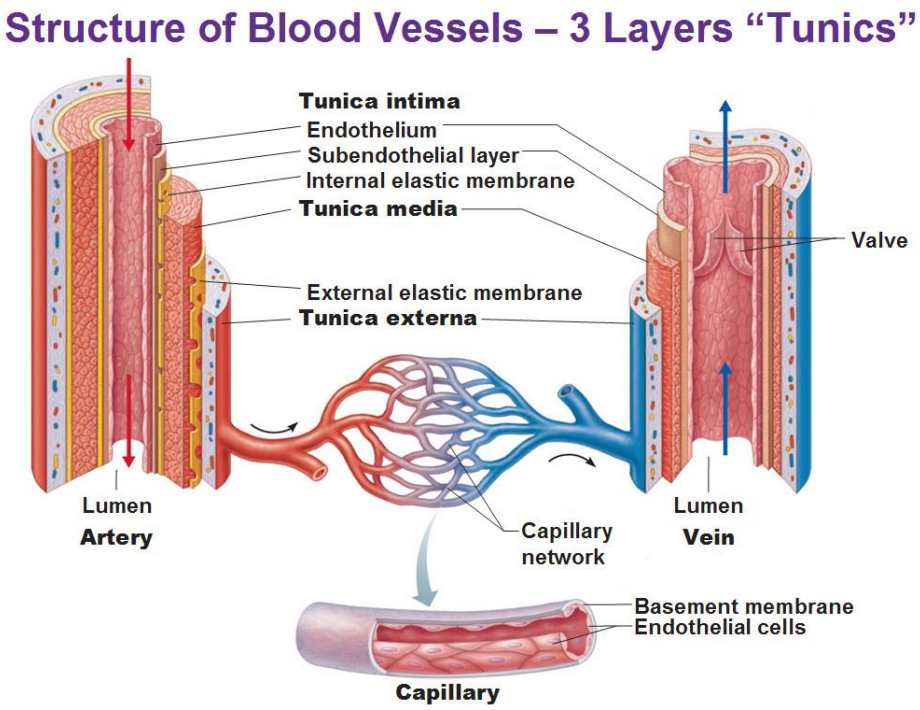
amount of blood under reduced pressure and have valves to prevent backflow and loss of pressure (Boore, Cook and Shepherd, 2016; Nair, 2017).

Image 4: Functions and differences between arteries, veins and capillaries

Arteries	Veins	Capillaries
•Carry blood away from the heart •Carry oxygenated blood (pulmonary and umbilical arteries are the only exception) •Wall consists of tunica interna, tunica media and tunica externa ***(see image 3)*** •Contain more elastic tissue than veins •Do not have valves and have a narrow lumen •Transport blood under higher pressure than veins	•Carry blood from the capillaries back to the heart •Carry deoxygenated blood (pulmonary and umbilical veins are the exception) •Wall consists of tunica interna, tunica media and tunica externa ***(see image 3)*** •Contain only a small amount of elastic tissue •Contain valves and have a wide lumen •Transport blood under lower pressure than arteries	•These enable the exchange of water, chemicals and nutrients between blood and tissues •Often referred to as the microcirculatory system •Act as a bridge between veins and arteries •Wall consists of a very delicate tunica externa layer ***(see image 3)***

Source (Boore, Cook and Shepherd, 2016; Nair, 2017)

Image 5: Layers of a blood vessel (BJN to insert image – see example below)



Blood pressure measurement readings

Key Facts

1. A blood pressure reading is calculated by obtaining a systolic and diastolic reading and is documented as a fraction:

$$\frac{\text{Systolic}}{\text{Diastolic}} = \frac{120}{80}$$

2. Blood pressure is measured in millimetres of mercury (mmHg)
3. Blood pressure can be obtained manually, via electronic methods, invasively and non-invasively.

BP measurement consists of two readings, which are documented as a fraction (Moore, 2017). The uppermost reading, known as the systolic, is the first measurement taken and is associated with the peak force of blood exerted from the heart, when the left ventricle contracts and pushes blood into the aorta, causing an increase in pressure (Fetzer, 2014: Foley, 2015). Whilst the lower reading, the diastolic, relates to the exerted blood force, on the walls of the blood vessels while the heart relaxes and refills (Bishop, 2009). (Platt, Conolly and Round, 2013) state that despite intermittent ejection of blood from the heart and rapid changes in pressures within the aorta, blood flow around the body remains continuous due to the aorta's ability to store potential energy during systole and convert this back to kinetic energy during diastole.

There are multiple factors which can influence a BP reading such as age, sleep, emotions and activity; consequently, evidence with the literature varies as to what constitutes as a normal BP reading, and optimal parameters are often used instead (Moore, 2017). Dougherty and Lister (2015) state that a normal BP at rest ranges between 110-140mmgs for the systolic and 70-80mmhg for the diastolic. Hypertension (high BP) refers to BP measurements that exceed the resting systolic parameters and hypotension (low BP) refers to measurements that fall below the resting systolic parameters (Perry, Potter and Ostendorf, 2014). Hypertension and hypotension if left

undetected and managed can have serious implications to an individual, including reduced tissue perfusion if hypotensive and cardiac ischemia if hypertensive (Wallymahmed, 2007).

How can blood pressure be undertaken?

BP can be measured using varying techniques, including, invasively or non-invasively and through manual or electronic devices, each with strengths and limitations ***(see image 6)***.

Invasively via arterial cannula

This is the preferred method of choice for patients who need constant monitoring and are more acutely unwell, and need critical care (Platt, Conolly and Round, 2013). Beale *et al.* (2004) concur that the continual monitoring of blood pressure can be possible via an arterial cannula which although invasive is more reliable than a sphygmomanometer or non-invasive oscillometry. The most commonly used arteries are the radial due to the ease of access, but the brachial, femoral and dorsal pedis can also be used (Bersten, 2004). Another benefit of using an invasive method via a cannula device is that the effects of these lifesaving treatments and medications can be monitored and observed immediately (Overgaard and Dzavik, 2008). Once the cannula is inserted it is attached to an infusion set containing a pressurised transducer, a pressurised bag (300mmHg) of 500ml 0.9% sodium chloride and a pressure monitoring system; however, due to the increased number of component parts to this monitoring process this technique has a greater number of risks and complications associated with it, i.e. infection and reading error due to incorrect placement of transducer (Platt, Conolly and Round, 2013).

Non-invasively via electronic or manual devices

While the manual auscultation technique (listening for Korotkoff sounds) is considered the gold standard for BP measurement, advances in medical technology have led to a number of alternate ways to measure and monitor BP using electronic oscillometry (James and Gerber, 2017). The Nursing and Midwifery Council (NMC) (2018) and The National Institute for Health and Care Excellence (NICE) (2011) advocate the use of manual and technological devices. However, as there are advantages and disadvantages to both methods, a level of clinical knowledge and skill for manual and electronic measurements are a requirement within clinical practice. Moreover, while electronic devices have become the “go-to method”, remaining skilled and confident with the manual method is essential (Moore, 2017) especially for patients with hypertension, hypotension or pulse irregularities. As oscillometry is less accurate in patients with pulse irregularities and oscillometry tends to overestimate low pressures and underestimate high pressures (Bersten et al., 2004; Al-Shaikh and Stacey, 2007; Foley, 2015). The widespread introduction of electronic devices in clinical settings has seen reports in the decline of the ability to take manual BP readings (Mulryan, 2011). Kelsall-Knight and Diegnan (2015) further note the risk to nurses and student nurses becoming de-skilled in the manual technique due to the over reliance on electronical devices to take blood pressure. It is therefore recommended that nurses and student nurses regularly practice the manual blood pressure technique in order to remain competent and safe practitioners (Smith, 2016).

These inaccuracies in electronic readings can lead to false diagnosis and incorrect treatment (Bishop, 2009; NICE, 2011) and if there are any doubts over an electronic BP reading, a manual reading should be obtained in order to verify a patient's BP (Dougherty and Lister, 2015). Using clinical judgement when doubts arise within

clinical practice is often associated with the art of noticing (Tanner, 2006: Watson and Rebair, 2014: Lancaster, Westphal and Jambunathan, 2015). Failure to interpret and ultimately respond appropriately to clinical cues to uncover clinical signs of deterioration (Lancaster, Westphal and Jambunathan, 2015) linked to changes in BP, can lead to serious consequences (Watson and Rebair, 2014). Therefore, while electronic devices might give a BP reading that is within normal parameters, doubts with the device's accuracies can arise from being able to clinically notice signs of deterioration in relation to BP.

Image 6: Strengths and limitations of blood pressure recording devices

Invasively via arterial cannula	Non-invasively via electronic or manual devices
• Used for patients requiring critical care • Provides continual monitoring of arterial blood pressures • More effective at monitoring immediate responses to treatment and medications • Need to penetrate the skin and enter an artery; thus this technique is associated with a variety of risks, i.e. infection, air emboli and thrombus formation • More costly due to the number of equipment and components required i.e. transduction system, monitors and fluid etc. • As a range of equipment is required there are often more issues associated with equipment failure and problems with the transducer i.e. position not at thge level of the right atrium and pressure of fluid etc.	• Used for patients who are not expected to expereince rapid changes in blood pressure • Provides intermittent measurement of arterial blood pressures • Non-invasive and therefore associated with fewer risks and reduced harm • Associated with lower costs in terms of equipment purchasing and maintenance • Healthcare professional need to maintain skills assocated with listending to the Korotkoff sounds • If the incorrect cuff size is used readings will not be accurate • Electronic oscilmmotery less accurate in patoinet with pulse irregularities and with extemes in high and low blood pressure readongs

Source (Beale et al., 2004; Bersten, 2004; Overgaard and Dzavik, 2008; Platt, Conolly and Round, 2013)

What is involved when taking a manual BP?

BP can be measured using a number of different arteries; however, due to ease of access, the manual technique is generally associated with measuring the brachial

arterial pressure, a major blood vessel that runs through the upper arms before dividing below the anti-cubital fossa (ACF) (Bishop, 2009; Netter, 2014; Allan and Sheppard 2018). To take a manual BP, two main pieces of equipment are required; an aneroid sphygmomanometer (Figure 1.1) and a stethoscope (Figure 1.2). The sphygmomanometer consists of a cuff which houses an inflatable bladder, a manometer (dial) and a mechanism to pump up the cuff, known as the inflation bulb. In order to measure BP, the inflation bulb is depressed, and the air inside is forced into the bladder in the cuff, once the bulb is released, air re-enters the bulb, and the process is repeated. During this process, the pressure within the bladder situated in the cuff will fill to a point where the cuff pressure exceeds the blood flow in the brachial artery. The cuff, therefore, acts as a tourniquet, as it temporarily excludes blood flow to the artery (Bishop, 2009). By opening the valve attached to the inflation bulb, the air is slowly released from the bladder, the cuff pressure falls, and when the systolic pressure becomes greater than the pressure remaining in the cuff, a sound will be heard through the stethoscope (Levick, 2010). The sounds that can be heard are referred to as Korotkoff sounds, and these can often be described as tapping, thudding or ticking sounds, and it is the first Korotkoff sound that is used to determine the systolic reading (Foley, 2015). As the air continues to be released from the bladder, the pressure in the cuff decreases further, restrictions on the arteries are reduced, blood flow starts to return to normal, and the Korotkoff sounds will disappear indicating the diastolic reading (Fetzer, 2014).

How to take a manual BP BJN to tabulate this

Poor technique is another factor that can lead to inaccuracies in BP measurements; therefore, it is important to follow the correct technique (Moore, 2017).

1. Ensure you adhere to infection prevention (i.e. hand hygiene, personal protective equipment (PPE), decontaminate equipment).
2. Communicate with the patient, explain the procedure fully and gain consent.
3. Position your patient (i.e. supine, seated or standing) and choose an appropriate arm to take the BP reading (i.e. avoid fistulas, broken areas of skin, mastectomy sites, and cannula sites).
4. Gather, check and prepare the equipment. All BP devices should be checked and calibrated according to the manufactures instructions (i.e. check for damage, and check that the dial is at zero. Not checking or calibrating the equipment can lead to inaccuracies). Ensure that the cuff size is correct for the patient, as if the cuff is too large for the patient, the BP reading can be underestimated. Cuff sizes are often displayed in picture form on the outside of the cuff (Figure 1.3). Ensure the stethoscope is in full working order, this will require you to twist the stethoscope head clockwise and gently tap on the diaphragm. If a loud sound can be heard the stethoscope is working correctly.
5. Locate the patient's brachial artery (Figure 1.4).
6. Wrap the cuff securely around the patient's bare arm, ensuring that the patient side of the cuff is placed against their skin, with the lower edges of the cuff 2-3cm above the brachial pulse. The cuffed arm should be at the level of the patient's heart to ensure an accurate reading (a pillow can be used to position the arm if required).
7. Ensure the patient is rested (patients should be seated comfortably for at least five minutes before taking a BP), and ask them not to talk or eat. Ensure their legs are uncrossed as crossed legs can increase blood pressure.

8. Relocate the brachial pulse, once found, palpate the pulse while inflating the cuff. When the brachial pulse can no longer be felt deflate the cuff, ensuring that you take note of the reading on the manometer (dial). To estimate the systolic pressure add 30mmhg to the measurement you recorded, this is known as the patient's approximate systolic BP (Figure1.5). Gaining an approximate systolic is considered a good practice as this is used as an indication of a patient's BP and further acts as a gauge to reduce the risk of the systolic reading being missed. It also reduces the potential discomfort that can be caused if the cuff is unnecessarily overinflated.
9. Place the stethoscope into your ears, ensuring the earbuds are facing forward and position the diaphragm of the stethoscope over the patient's brachial pulse (Figure 1.6).
10. Inflate the cuff to the approximate systolic previously noted.
11. Slowly deflate the cuff 2-3 mmHg per second, while simultaneously listening for the first Korotkoff sound (tapping sound notifying the systolic reading) and the Kororkoff disappearing (this signifies the diastolic reading).
12. Once Korotkoff sounds can no longer be heard, open the valve to deflate the cuff fully. If you need to re-check the BP ensure you wait 1-2 minutes.
13. Remove the cuff, decontaminate the equipment and document the reading. (Dougherty and Lister, 2015: O'Brien, 2015: Moore, 2017: British and Irish Hypertension Society, 2017).

<u>Common causes for errors</u>

Top tips for using a stethoscope

Inaccuracies with the readings often result from reduced hearing, caused by the incorrect opening of the diaphragm of the stethoscope and incorrect insertion of the stethoscope earpieces (being inserted in the wrong direction into the ear canal).

- Before inserting the stethoscope make sure the earpieces are pointing forwards towards the bridge of your nose.
- Once the stethoscope is in-situ check the diaphragm is open by taping the end of the diaphragm gently, if a loud sound can be heard, the diaphragm is working correctly. If no sound can be heard, turn the stethoscope head 180 degrees and repeat the above process.
- Some stethoscopes have duel auscultation devices (diaphragm and bell). The diaphragm is identified by its flat larger surface area which makes it easier to control when using a one-handed technique.
- Ensure that the diaphragm is placed over the brachial artery and not the bell.

Tops tips for cuff application

Loose and incorrectly placed cuffs are a common problem associated with inaccurate BP measurements.

- The midline of the bladder should be placed 2-3cm above the brachial pulse. Most cuffs now have an arrow to indicate the midline point. The arrow needs to be pointing down toward the brachial (Figure 1.7 & Figure 1.8)
- The cuff should be secured so it is comfortable and cannot slip off the arm.

Tops tips for using the valve on the inflatable bulb and reading the measurements on the dial

Opening, closing and controlling the valve, in particular, the speed is a common problem that causes inaccuracies in readings.

- Before carrying out the procedure, confirm which direction opens and closes the valve.
- Opening and closing the value slowly comes with practice. Practising a one-handed technique for slowly opening and closing the valve is essential.
- Ensure the sphygmomanometer is placed at eye level and that the dial on the meter is visible.

(Wallymahmed, 2007; Tomlinson, 2010; Dougherty and Lister, 2015)

Images for taking a manual BP
(all images are the property of Northumbria University)

Figure 1.1

Figure 1.2

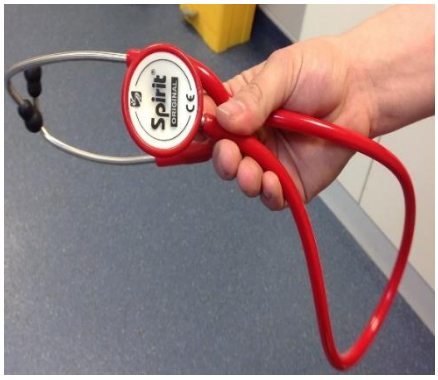


Figure 1.3

Figure 1.4

Figure 1.5

Figure 1.6

Figure1.7

Figure 1.8

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