SPHYGMOMANOMETRY (BLOOD PRESSURE)

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Sphygmomanometry, the measurement of blood pressure (BP), is a useful complementary test of an optometric assessment. The BP measurement serves as a screening method for the frequently asymptomatic patient with suspected or poorly controlled hypertension and cardiovascular disease. A BP assessment may also be valuable when pharmacological agents are used in eye care as some medication may have potentially deleterious side effects in people with severe hypertension or cardiovascular problems. Finally, because the eye is an important target organ of many vascular diseases, blood pressure measurement is useful in the diagnosis and management of both ocular and systemic diseases, some of which can be sight-threatening or even fatal (Table 1.1).

- Chronic open angle glaucoma
- Low tension glaucoma
- Repeated spontaneous subconjunctival hemorrhages
- Hypertensive retinopathy
- Retinal embolic phenomena
- Transient ischemic attacks
- Amaurosis fugax
- Headache
- Papilledema

Table 1.1: *Clinical conditions where BP Measurement complements the clinical diagnosis*

THEORY

Arterial pressure varies during the cardiac cycle. At the end of the ventricular contraction, when the ventricle finishes pumping blood into the aorta, the arterial pressure within the vascular system reaches the maximal systolic pressure. As the ejected blood is distributed throughout the vascular system during the relaxation phase of the ventricle, arterial pressure gradually decreases to reach the minimal diastolic pressure.

Systolic and diastolic pressure can be measured directly by inserting a catheter into a major artery that is connected to a manometer or electronic recording device. This is an invasive method used principally in critical care settings or in animals for experimental purposes.

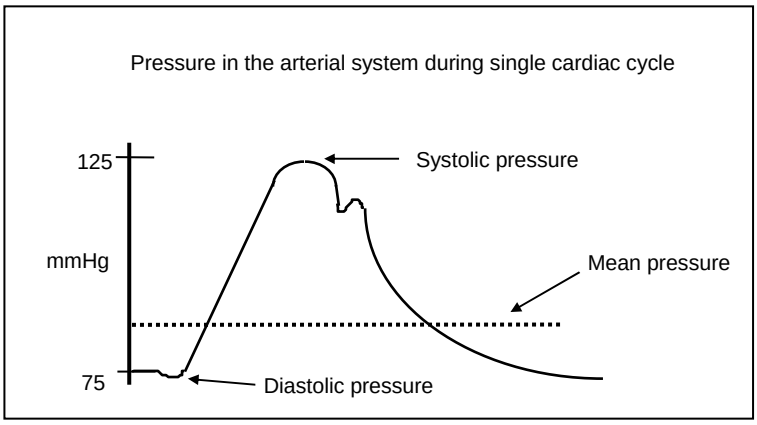

Figure 1.1: *Pressure in the arterial system during a single cardiac cycle*

Clinically, blood pressure is usually evaluated indirectly by wrapping an inflatable bladder around the arm to oppose the pressure in the brachial artery and listening to the resulting *Korotkoff* sounds. The Korotkoff sounds are produced by the blood opening and swirling through the brachial artery when the outside pressure compresses it. Normally, no Korotkoff sound is heard when the artery is either fully shut or fully opened. Sounds are only heard when the blood forces open the artery and swirls between the vessel walls against a certain resistance.

Consider an air-filled bladder wrapped around the upper arm, where the brachial artery runs. In addition to being easily accessible and compressible, the brachial artery also offers the key benefit of being located near level of the heart, an important fact to obtain an accurate blood pressure measurement. If the pressure in the bladder is increased until its pressure is higher than the highest arterial pressure (systolic pressure), the brachial artery will collapse and blood flow will cease, at which time no Korotkoff sound will be heard. As the bladder pressure is decreased by releasing air from an adjustable valve, blood in the brachial artery will first flow when the pressure within the artery is slightly greater than the pressure compressing it (systolic pressure $\approx$ bladder pressure). At this point, a first Korotkoff sound will be heard.

During the relaxation phase of the artery, however, the pressure within the artery will gradually fall reaching a point below the bladder pressure at which point the artery will collapse again, until the next systolic contraction. This cycle will continue if the bladder pressure is kept constant. However, if the bladder is further deflated, the pressure within the artery will exceed the bladder pressure and open the brachial artery for a longer segment of the cardiac cycle. A point is eventually reached where the bladder pressure is too low to ever compress the artery against even the lowest pressure within the vessel (diastolic pressure $\approx$ bladder pressure). At this point, the Korotkoff sound will cease.

The Korotkoff sounds vary in loudness throughout the cardiac cycle. The intensity of sound throughout the cardiac cycle is depicted in Figure 1.2. The systolic and diastolic pressure correspond to the first and the last Korotkoff sounds respectively (stage I & V) (Fig. 1.2).

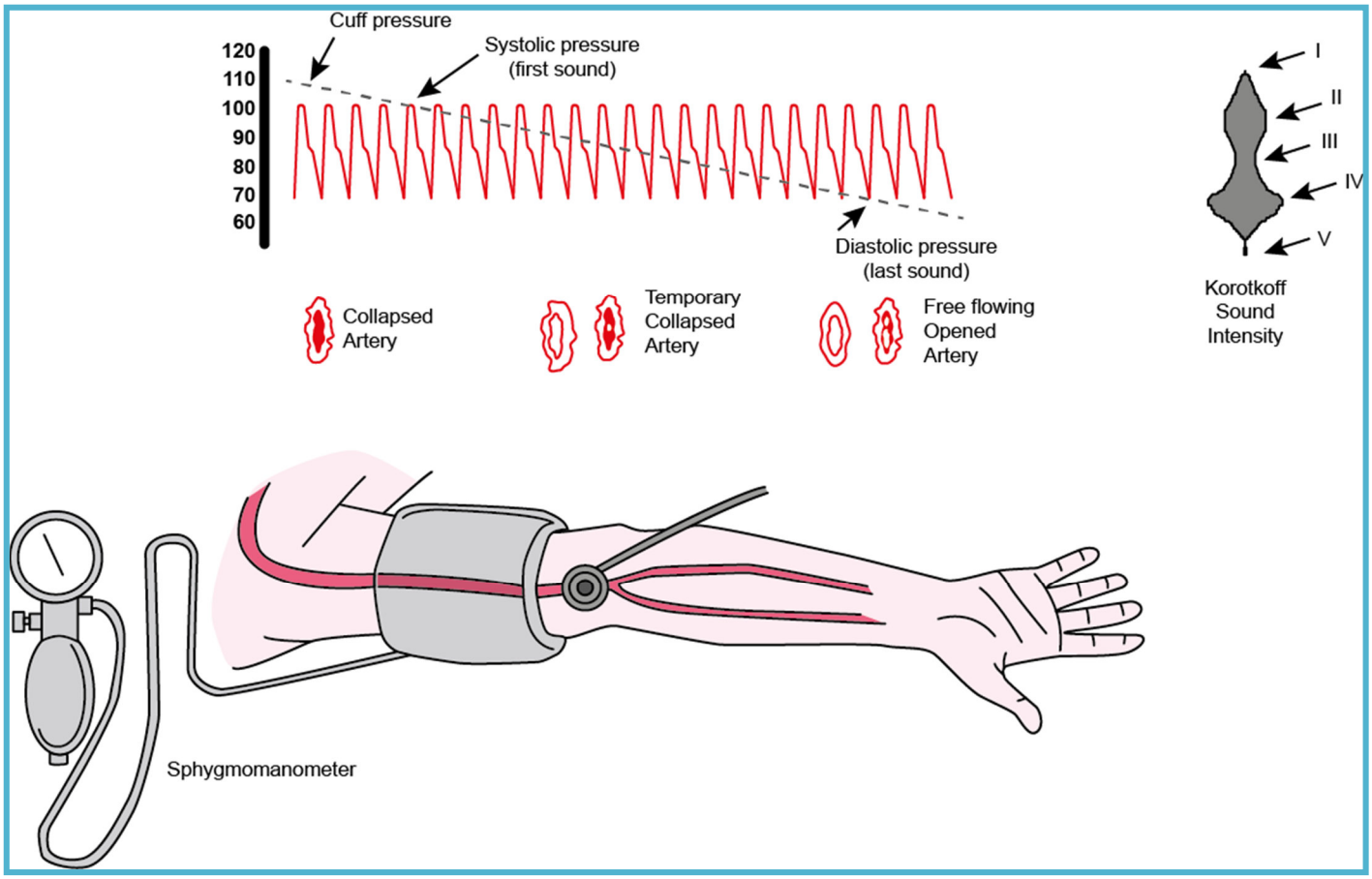

Figure 1.2: *Set up and phases of a blood pressure measurement*

Inspired by Raffery EB: The Methodology of blood pressure recording. Br. J Pharmacol 1978; 6: 193-201

INSTRUMENTATION

Using the above principle, the arterial pressure is measured with a sphygmomanometer and a *stethoscope.*

The sphygmomanometer or blood pressure meter is a device composed of an inflatable bladder inside an unyielding cuff that can be wrapped and tied around the arm and inflated with a bulb. The bladder is connected to a measuring device, usually a mercury column, an electronic or mechanical manometer, that indicates the pressure within the bag in millimeters of Mercury (mmHg). The column of Mercury is the standard by which pressure measurements are denoted.

Pressure cuffs are available in various sizes for the newborn, infant, child, adult, and large adult. In many clinical settings, an adult size is used as an all-purpose measuring cuff. The clinician must however bear in mind that the use of an inadequately sized BP cuff will yield significant errors in the measurements. The ideal bladder width should cover 40% of the arm circumference (2.5 X the width = arm circumference). Conveniently, most bladders are 2X their width; the proper length of the inflatable bladder should therefore cover approximately 80% of the arm's circumference.

The stethoscope, an instrument used to amplify the Korotkoff sounds, generally consists of earpieces, binaural, rubber tubing and a chest piece. The chest piece can be composed of a single flat base surface (diaphragm) used to capture higher frequency sounds or include 1 to 3 bells used to capture low frequency noises. Although debatable, the diaphragm is recommended for blood pressure measurement (Fig. 1.3).

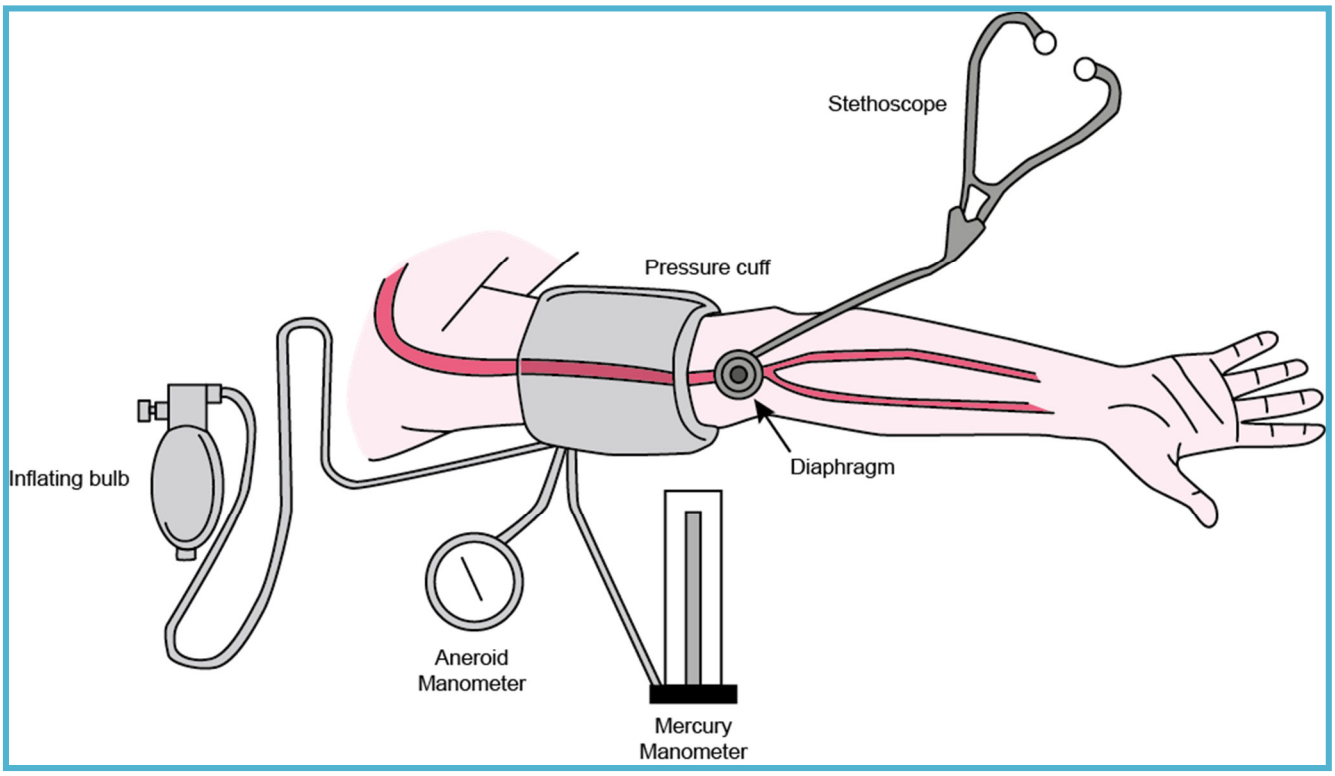

Figure 1.3: *Instrumentation used for blood pressure measurement*

PROCEDURE

- If not your own, clean earpieces of the stethoscope with alcohol
- Sit and rest the patient comfortably for at least 5 minutes
- Free the arm of clothing insuring that the rolled up sleeves do not compress the arm. If absolutely necessary, the BP can be evaluated through a thin layer of clothing
- The arm is then extended, slightly bent and rested on the chair arm (or held) with the palm facing upward
- Locate the brachial artery by palpating the inner aspect of the biceps muscle just above the level of the antecubital crease (elbow fold)
- Wrap the cuff securely but not too tight around the upper arm ~ 2,5 cm above the crease
- Insure proper alignment of the middle of the cuff above the artery
- Palpate the radial pulse with the index & middle fingers; avoid using the thumb as it has a detectable pulse
- Before inflating the cuff, make sure the cuff is approximately at the level of the heart. If necessary, support the patient's elbow to ensure the patient's arm remains relaxed
- Inflate the cuff at ~ 20-30 mmHg above the point at which the radial pulse disappears
- Place the stethoscope diaphragm firmly but gently over the brachial artery avoiding cuff contact
- Deflate the cuff by increments of 2-3 mmHg, listening for first (systolic) & last (diastolic) Korotkoff sounds
- Wait 1 minute; Repeat the procedure a second time and average the results
- If sounds are inaudible, consider elevating the arm during inflation of the bladder or after inflating it have the patient open and close the fist.

SYSTOLIC / DIASTOLIC; ARM USED; PATIENT POSITION; TIME

E.g. 150/90 RAS 13:45

- Use R,L for right/left; A for arm; S for sitting, U for upright, L for lying
- If pertinent, note additional comments such as cuff size or abnormal conditions.

SOURCE OF ERRORS

- Diurnal Variation
- Interobserver variability
- Arm used
- Weak or inaudible Korotkoff sounds
- Orthostatic hypotension

Table 1.2: *Possible Sources of Variability in BP Readings*

Falsely Low Readings:

- Cuff too big (wide)
- Cuff deflated too rapidly
- Arm level above heart level
- Auscultatory gap*
- Placing chest piece under cuff

Falsely High Readings:

- Patient anxiety, fear emotional distress
- Cuff too small (narrow)
- Cuff too loose
- Cuff deflated too slowly (diastolic)
- Cuff deflated too rapidly (diastolic)
- Pseudohypertension (medial sclerosis and/or calcification of arteries)
- Arm level below heart level

Table 1.3: *Possible Sources of Error in BP Readings*

*An auscultatory gap is a period of abnormal silence or diminished intensity during one of the Korotkov sound phases.

BP Range (mmHg)	Category	Recommended Follow-up
Adults (> 18)		
≤ 95/60	Hypotension	Routine unless symptomatic
Diastolic		
< 85	Normal BP	Recheck within 2 years
85-89	High-normal BP	Recheck within 1 years
90-104	Light hypertension	Confirm within 2 months
105-115	Moderate hypertension	Obtain medical care within 2 weeks
≥ 115	Severe hypertension	Obtain immediate medical care
Systolic	*(when diastolic < 90)*	
< 140	Normal BP	Recheck within 2 years
140-159	Borderline isolated systolic HTN	Confirm within 2 months
≥ 160	Isolated systolic HTN	Confirm within 2 months
≥ 200	None given	Obtain medical care within 2 weeks
Children		
< 135/90	Ages 14-18 years	Routine
< 125/85	Ages 10-14 years	Routine
< 120/80	Ages 6-10 years	Routine
< 110/75	Less than 6 years	Routine

Table 1.4: *BP classification with the Recommended Guidelines for medical follow-up based on initial readings. Specific medical conditions may modify interpretation of blood pressure values*

REFERENCE

- Eskridge, J.B., Clinical Procedures in Optometry, Lippincott Williams & Wilkins, January 1991.