

Methods and devices of blood pressure measurement

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Why Blood Pressure?

- Accurate Blood Pressure Measurement is the first step in treating hypertension or high blood pressure.
- 30% done inaccurately
- Primary factor in 68% of heart attacks and 75% of strokes.
- Hypertension is one of the major modifiable risk factors for many cardiovascular diseases

A few definitions

- Blood Pressure- measurement of the force exerted by blood against the walls of the arteries
- Systolic blood pressure- the pressure in the large arteries when the heart is contracted
- Diastolic Blood pressure- the pressure in the large arteries when the heart is relaxed

More definitions

- Hypertension- PERSISTENT elevation of either diastolic or systolic blood pressure
- Essential (primary) hypertension- high blood pressure with no identifiable cause
- Secondary hypertension- high blood pressure with a known cause

Steps for Measuring Blood Pressure

- Seated for 5 minutes
- Patient Position
- Expose Upper arm
- Center of upper arm at heart level



Steps for measuring cont.

- Cuff applied 1 inch above crease at elbow
- Locate brachial artery
- Palpate radial pulse
- Inflate cuff until pulse disappears

Use an appropriate size cuff

Arm circumference (cm)	Size of Cuff (cm)
From 18 to 26	9 x 18 (child)
From 26 to 33	12 x 23 (standard adult model)
From 33 to 41	15 x 33 (large)
More than 41	18 x 36 (extra large, obese)

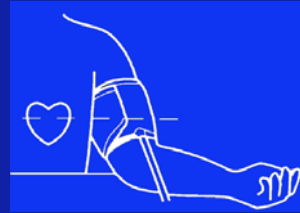
Recommended Technique for Measuring Blood Pressure (cont.)

- Locate the brachial pulse and centre the cuff bladder over it
- Position cuff at the heart level
- Arm should be supported



Recommended Technique for Measuring Blood Pressure (cont.)

- To exclude possibility of auscultatory gap, increase cuff pressure rapidly to 30 mmHg above level of disappearance of radial pulse
- Place stethoscope over the brachial artery
- Let air out at 2 mmHg per second



Factors affecting BP measurement

Factor	Systolic BP	Diastolic BP
Talking	↑ 17mm Hg	↑ 13mm Hg
Exposure to cold	↑ 11mm Hg	↑ 8mm Hg
Ingestion of alcohol	↑ 8mm Hg	↑ 8mm Hg
Supine	No effect	↓ 2-5mm Hg
Arm position above heart	↑ 8mm Hg/10cm	↑ 8mm Hg/10cm
Arm position below heart	↓ 8mm Hg/10cm	↓ 8mm Hg/10cm
Arm not supported	↑ 2mm Hg	↑ 2mm Hg
Cuff too small	↓ 3 mm Hg	↑ 8mm Hg

What would you tell a person about their blood pressure reading?

- Definition of Blood Pressure
- Numerical Value
- Blood Pressure Category
- When to Recheck
- Medications if Necessary
- Lifestyle Modifications

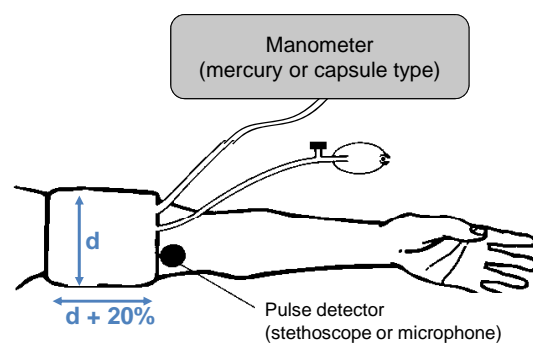
Measurement of blood pressure

- Invasive
 - Pressure catheter and transducer
- Non invasive
 - Sphygmomanometry
 - Auscultation (by ear or automatically by microphone)
 - Oscillometry
 - Volume clamp
 - Tonometry

Advantages/ drawbacks

- Invasive
 - Accurate reproduction of central pressure waveforms
 - Risk of thrombosis and arrhythmias
- Non-invasive
 - Quick, cheap, widely used
 - Lack of central pressure measurement
 - Requires skilled and experienced operators

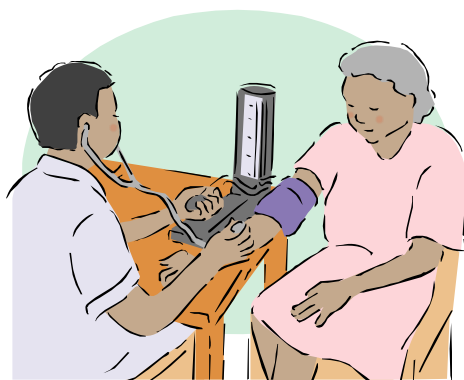
Sphygmomanometry



Sphygmomanometry

- 1896 Blood pressure cuff (Riva Rocci)
- 1905 First report of audible detection of heart sounds used with cuff (Korotkov)
- 1968 Microphone used for automatic pressure measurement (Stegall)

Sphygmomanometry



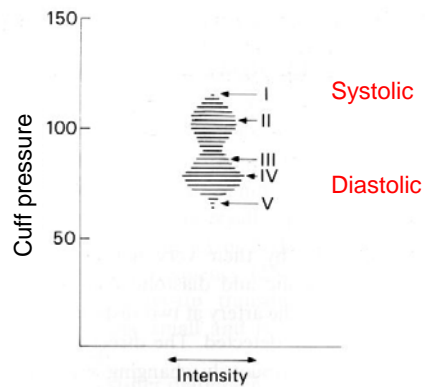
Mercury sphygmomanometer



Capsule manometer
Replacing mercury sphygmomanometer

Korotkov Sounds

caused by vibrational collapse of the arterial wall??



— Korotkoff V is the commonly recommended measuring point except in pregnant patients because:

- It is associated with less inter-observer variations
- It is easier to detect by most observers

www.fmshk.com.hk/sahk/lecture_noninvasive.pp

Korotkoff's Sounds

- ❖ Phase 1 A sharp thud
- ❖ Phase 2 A blowing or swishing sound
- ❖ Phase 3 A softer thud than sound 1
- ❖ Phase 4 A softer blowing sound that disappears
- ❖ Phase 5 Silence

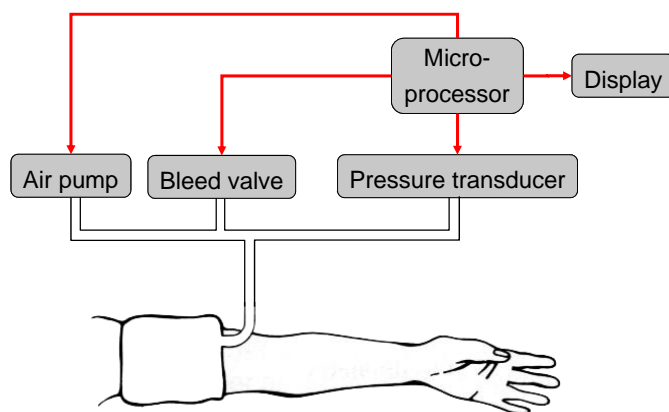
Errors

- Korotkoff sounds compared to invasive blood pressure measurement
 - Korotkoff IV is on average 8mm Hg above the invasively measured diastolic blood pressure
 - Korotkoff V is on average 2mm Hg above the invasively measured diastolic blood pressure

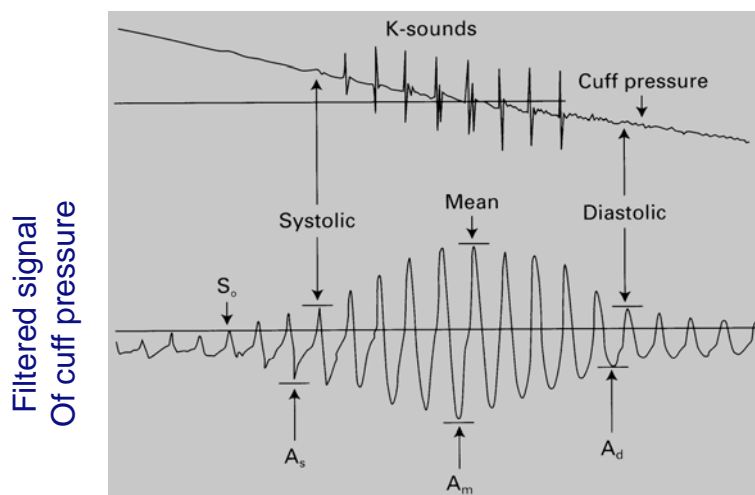
Oscillometry

- Cuff round the arm
- Pressurise cuff (> systolic)
- Allow pressure to drop slowly to zero
- Measure pressure in the cuff during deflation

Oscillometry: set up



Principle of oscillometry



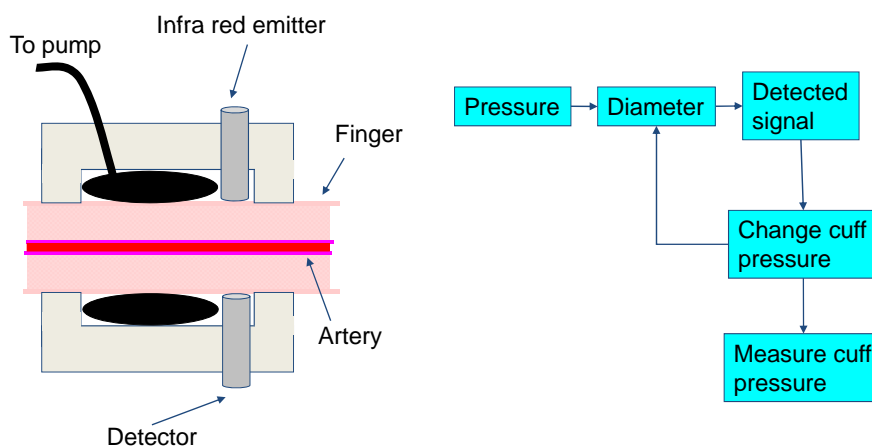
Limitations

- Inaccurate / unreliable in shock patients
- Inaccurate / unreliable in patients with arrhythmias
 - The algorithm of measurement assumes a regular pulse, so the reading is unreliable in patients with irregular pulse

Advantages

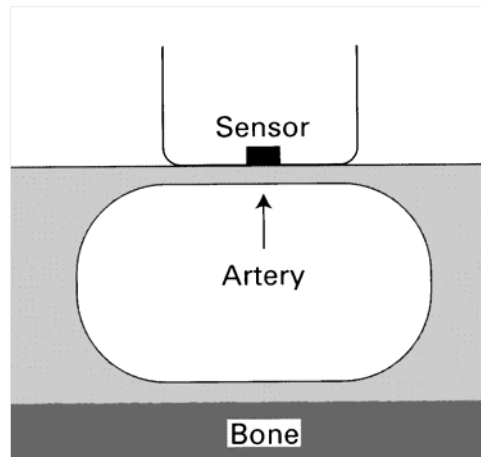
- No skill required
- No subjective errors

Volume clamp



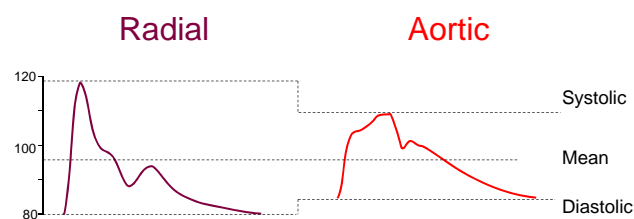
Applanation tonometry

Detects pressure of arterial pulsations through the skin



Problem:

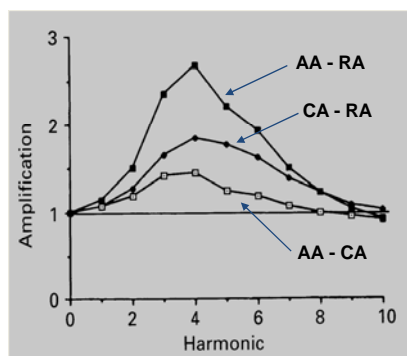
- Aortic and peripheral pressures are different.
- The heart doesn't care what the pressure is in the radial artery.
- It only "sees" aortic pressure.
- Aortic pressure is difficult (impossible?) to measure non-invasively
- Can we reconstruct the aortic waveform from the radial?



Yes we can. At least in principle

- Record radial waveform with tonometry
- Apply *inverse transfer function*
- “Reconstruct” aortic waveform
 - What is an inverse transfer function?
 - How do we reconstruct the waveform?

Amplification of the pulse

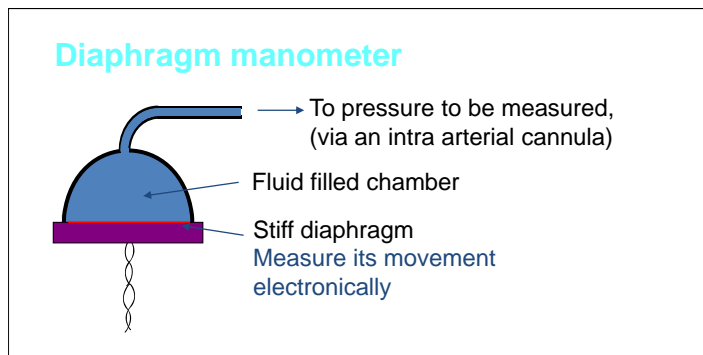


How to derive the central pressure from peripheral measurements

- Compare Fourier series of “typical” aortic pressure waves with Fourier series of the radial pressure computed from tonometric measurements.
- Calculate the amplitude ratio and phase difference for each harmonic
- Apply this ratio and phase difference to each harmonic of the measured radial wave and reconstruct aortic wave that would when transmitted down the arm, producing the measured radial wave

Pressure transducers

(for invasive measurement)



Advantages

- Cheap, disposable
- easy to use
- Accurate mean pressure

Disadvantages

- Clotting in cannula, air bubbles
- Therefore errors in pulse pressure

Pressure transducers

(for invasive measurement - 2)

Cannula tip manometer

Semi conducting strain gauge



Diameter may be as small as 0.67 mm

Advantages

- High accuracy
- Especially in very small vessels

Disadvantages

- No calibration possible when in position
- Expensive
- Fragile

Pressure: comparison of methods

Method	Sensitivity	Invasive	Advantages/ disadvantages
Auscultation + cuff	OK	No	Subjective, limited to arm or leg. Good in skilled hands
Oscillometry + cuff	OK	No	As above but less subjective. No mean pressure.
Catheter	Good	Yes	Only direct way to measure in central vessels
Volume clamp	Good	No	Limited to peripheral arteries but can do small ones
Tonometry	V. Good	No	Superficial vessels only, sensitive to movement, good for carotid. No absolute P values. Can be calibrated against cuff methods
PPG	V. Good	No	Superficial vessels only. Used as a pulse detector in conjunction with cuff. PROMISING

Conclusion

- Blood pressure measurement is a crucial aspect in the diagnosis of HTN.
- HTN is not diagnosed with only one reading.
- Several steps should be taken to ensure a correct reading.
- There are many ways to measure the blood pressure whether invasively or non-invasively.

Self Assessment

Normal Blood Pressure in Adults (18 or older) is:

- a. 115/75
- b. Below 120/80 mmHg
- c. Below 160/90 mmHg
- d. Depends on your age

Which of the following can cause sounds to be heard down to zero mmHg?

- a. Anemia
- b. Vigorous exercise
- c. Heavy pressure on the stethoscope
- d. All of the above

If the cuff is applied too loosely, the pressure reading will be:

- a. Too low
- b. Too high
- c. Not affected

Common causes of errors in blood pressure measurement include:

- a. Dirty mercury or dirty glass tube
- b. Cuff applied over clothing
- c. Leaks in the pressure bulb or tubing
- d. Arm above or below heart level
- e. All of the above

Some factors that can alter blood pressure are:

- a. Smoking
- b. Anxiety and other emotional states
- c. Talking
- d. Full bladder
- e. All of the above
- f. B & D only

When using the Auscultatory-Palpatory technique of blood pressure measurement, the pressure in the cuff should be raised:

- a. 20-30 mmHg higher than the point where the pulse disappeared.
- b. 30 mmHg higher than the systolic pressure
- c. 20 mmHg higher than the systolic pressure

While taking a blood pressure, the first sound heard through the stethoscope is at 150 mmHg and sounds are heard from “150” until the last sound is heard at 78 mmHg. What is the patient’s blood pressure?

- a. 150/78
- b. 148/76
- c. 150/76
- d. 148/78

The patient, a 25- year old white male, has just run up five flights of stairs- what action should be taken?

- a. Have the patient rest 5 minutes and then proceed with measurement
- b. Wait until pulse has returned to normal before measuring blood pressure
- c. Have patient return in 30 minutes for blood pressure check- advise the patient not to do any exercise or other strenuous activity before returning.

To avoid incorrectly assessing the systolic blood pressure due to the auscultatory gap, the auscultatory-palpatory technique of blood pressure measurement should always be used.

- a. True
- b. False

A diagnosis of hypertension (high blood pressure) cannot be made from one blood pressure reading

- a. True
- b. False

You shouldn't have your blood pressure checked immediately after smoking.

- a. True
- b. False

If the initial blood pressure reading is greater than or equal to 120/80, two or more readings should be taken.

- a. True
- b. False