3.1 Sphygmanometers:

Sphygmanometers are used to measure patient blood pressure (BP). Ideally they are low range, accurate pressure gauges. Sphygmanometers require a gauge, pressure cuff, inflator or bulb, pressure release valve and hoses. The most common range is 0-300 millimetres of Mercury (mmHg). There are two types, Mercury (Hg) and Aneroid. The mercury units use a column and a reservoir of mercury. Mercury is poisonous and very dangerous to handle. Great care must be taken when handling mercury. Under normal circumstances the mercury sphygmanometer is safe to use and handle. It is dangerous if the reservoir or glass column is broken.

The following points are important for accurate blood pressures: The inflatable part of the cuff must be the correct size for the arm. It should cover two thirds of the length of the upper arm. A blood pressure cuff which is too small will cause an abnormally high blood pressure reading and a low reading may result from too large a cuff. The cuff should be firmly applied with the centre of the inflatable part over the brachial artery.

There are four common sizes of BP cuffs. They are:

- Standard adult
- Large adult
- Child
- Neonate

There are also thigh cuffs available for use when it is not possible to take BP readings from the arms.

3.1.1 Mercury Sphygmanometer:

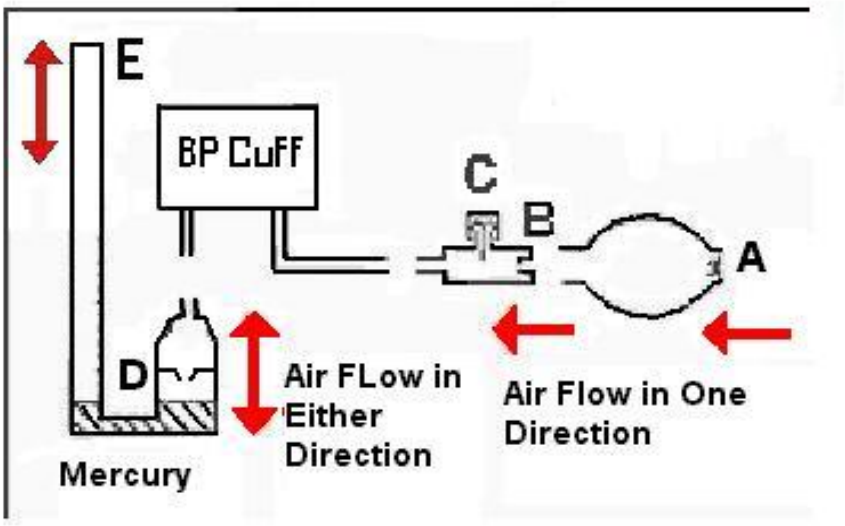


Fig 3.23-20

A mercury sphygmomanometer is operated by inflating a rubber cuff placed around a patient's arm until blood flow stops. A the air pressure rises, mercury is displaced in the reservoir and forced up the column. The cuff pressure is measured via the mercury column.The figure shows the parts of a mercury sphygmomanometer. The inflating bulb is used to inflate the cuff. It contains two one-way valves. Valve A allows air to enter the back of the bulb. When the bulb is squeezed this valve closes and the air is propelled through valve B to the cuff. Valve B stops the air going back into the bulb. The two leather discs (D and E) allow air to pass in and out of the column, but prevent mercury escaping from the sphygmomanometer.

3.1.2 Checking a Mercury BP Cuff:

- The cuff must be free of leaks.
- The mercury should be clean and at the zero mark before use.
- During cuff inflation the mercury should rise smoothly, and stop immediately when inflation stops.
- The mercury should appear shiny in the column with no visible irregularities:
  - Dirt
  - Dust
  - Sediment
  - Air bubbles
- Ensure the mercury indicates a zero reading when sitting on a flat and level surface with no pressure applied. If it does not indicate zero the sphygmanometer will require repair.

3.1.2.1 Problems with the mercury sphygmomanometer;

Caution: Mercury vapour is poisonous. Any maintenance should be performed in an area of good ventilation. Store mercury in a plastic bottle with a little water placed on top of the mercury. Be careful not to inhale black mercuric oxide powder during cleaning procedures.

A little black powder in the column does not matter. If there is a large amount, the mercury should be removed from the sphygmomanometer and the column and reservoir cleaned. Check local regulations first-not all jurisdictions permit removal of the mercury.

If legal proceed as follows:

- Lay the machine on its side with the reservoir downwards.
- Remove the column, ensure that you do not lose the leather disc at the top.
- Undo the reservoir top and pour the mercury out into a plastic bottle.
- Blow the reservoir and the leather disc in the reservoir top clean with compressed air and wipe with a cloth.
- Clean the inside of the column and replace it. In most situations it is possible to clean the column with a cotton swab or a small bottle brush. Remove all black dust.
- Replace or soften the leather disc at the top and the washer at the bottom with emollient.

- Clean the mercury in well ventilated conditions. For minor contamination it is possible to clean the Hg with a slow rotating motion of the cotton swab. In cases where the contamination is more pronounced use several layers of gauze as a sieve.
- Replace the mercury in the reservoir to the zero mark. Use a syringe and needle to draw up the mercury from the plastic bottle. Keep the needle under the surface of the mercury to avoid returning any black powder.

- Replace the reservoir top with its sealing ring and connect the cuff.

- Check the system is airtight by inflating the cuff until the mercury is at the top of the column. Ensure no mercury escapes. If a spill occurs the top leather disc is faulty or missing. This disc should allow the air to pass in and out as the mercury rises and falls, but not allow mercury to escape.
- Check that mercury does not continue to rise slowly after stopping inflation. This is caused by the air at the top of the column failing to escape through the top leather disc quickly enough as the mercury rises up the column. This fault may result in abnormally high readings as the mercury falls more slowly than the cuff pressure, due to the faulty leather disc restricting the air entering the top of the column.

  The cause of these faults is in the top leather disc. It is either too thick or dirty. It should be removed as described before and cleaned. Replace it and test the sphygmomanometer. If the fault persists, remove the disc. Holding it between your finger and thumb on a flat surface, gently scrape it with a scalpel blade. Turn it continually to ensure it keeps its round shape and take care not to put a hole in it. Refit.

- Check that the mercury rises instantaneously when the cuff inflates. If it does not this indicates blockage at D in the figure or a kinked or obstructed tube.

- Check for cuff inflation. If the cuff does not inflate. This indicates that there is a leak or a defective one way valve. Check valves A, B and C, the rubber bladder, tubing and connections. Rubber bladders may be repaired with an ordinary bicycle tire puncture kit. Valve B can usually be removed and cleaned. Valve A may be a small ball bearing or a needle valve which can be removed from its cage and, with care, cleaned and replaced. Valve C may sometimes be repairable with care. There are other valves that are not repairable.

- After full assessment reassemble the sphygmomanometer and test.

3.1.3 Aneroid Sphygmanometer:

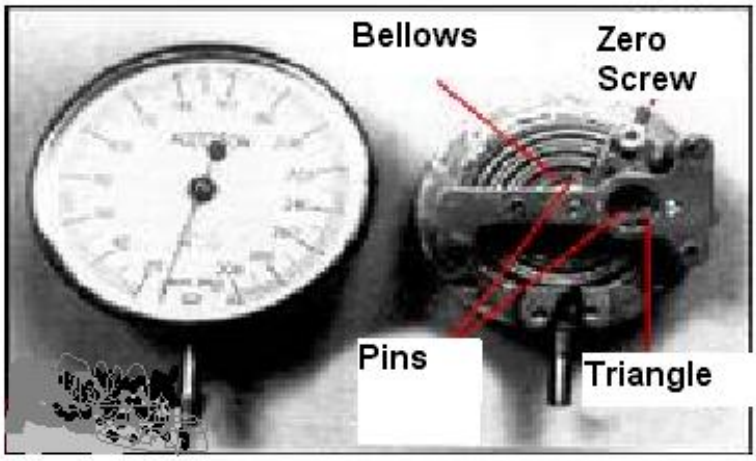
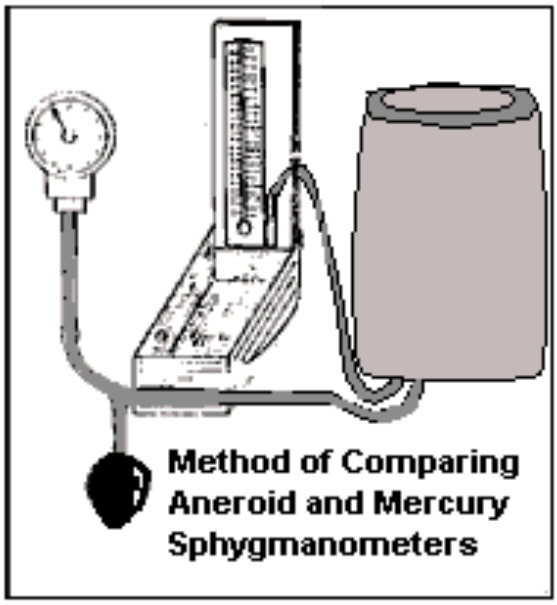


Fig 3.23-21

Aneroid , or air blood pressure gauges are generally smaller than mercury ones but they are easily damaged and can go out of calibration without detection. A common type of aneroid apparatus is shown in fig 3-21. It consists of a dial gauge which normally rises to 300mmHg and a thin brass corrugated bellows inside. There is a shaft which connects two pins at right angles to each other; one of these rests on the bellows, the other is inside a concave sided triangle which meshes with a pinion connected to the dial pointer. A thin coiled spring (known as a hair spring) is also connected to the pinion and returns the pointer to zero when the pressure is released. When in use the gauge is connected to a blood pressure cuff around the patient's arm. As the pressure in the cuff rises, the pin resting on the expanding bellows is lifted. This movement is transmitted by the other pin which moves the triangle and therefore the pinion and pointer. This may be seen in fig 3-22.

3.1.3.1 Checking an Aneroid BP Cuff:



Cuff around an incompressible object. Pressure is felt equally on the gauges, bulb and cuff

Fig 3.23-23

The following errors may occur: Leaks in the system. If a leak develops in the system wrap the cuff around itself and secure the end. Inflate the system to 250mmHg, and let stand for 1 min. The gauge must not decrease more than 10mmHg. If the drop in pressure exceeds 10mm the problem is most likely to be in the cuff, hoses or inflation bulb. It is fairly rare for a leak to occur in the gauge itself. Rapid leaks may be heard. Slow leaks may be found by restricting the hoses with a clamp to eliminate the source. A small pointed brush with soapy water on it will help find the smallest leak. Incorrect zero - the gauge does not return to zero after the cuff has been deflated. On some models, such as the example photographed, there is an adjustment screw to set the zero point. However using this screw requires the instrument to be taken out of the case and the screw may be very stiff. The easiest method of adjusting the zero is by removing the glass from the front of the gauge and carefully taking off the pointer, pry with two small flat screwdrivers and replacing it in the correct position. Lever the pointer upwards using one on each side.

3.1.3.2 Calibration check;

Every aneroid blood pressure gauge should be compared with a well maintained mercury sphygmomanometer on a regular basis. Connect the gauges together with a plastic T-piece and connect the third arm to an inflation bulb (figure 3-23). Inflate the bulb slowly and note the readings showing on each instrument on a piece of paper at readings of 20, 50, 100, 150, 200 and 250mmHg. After you have finished the test inspect the figures (example shown below) and note the difference between them. If the readings are within a few millimeters (4%) of mercury throughout the scale this is acceptable for clinical use.

Ex3.1 Linear or Zero error. In this case the readings are considered consistent in one direction. It is normal for an aneroid sphyghmanometer to have a slight variation in readings over a wide scale of 0-250mmHg. This variation is most likely caused by the needle not being centered in the zero range. This may be adjusted by removing and recentering the needle or by performing an adjustment on the bellows via the bottom inlet position. This fitting may be adjusted by loosening the fitting lock nut and readjusting. In some cases there is an adjustment screw that is visible inside the fitting when the hose is removed or inside the guage case on some others. It is not advisable to habitually adjust the needle position by removal and refitting as this will cause linearity error over time. Refer to Ex 3.2 for linearity error.

Applied Pressure mmHg	**Test Reading**	**Error**
20	30	+10
50	60	+10
100	108	+8
150	156	+6
200	208	+8
250	258	+8

Ex3.2 Linearity Error.

Applied Pressure mmHg	**Test Reading**	**Error**
20	20	0
50	50	0
100	106	6
150	160	10
200	218	18
250	260	10

In this case the error increases over the range of 0-250mmHg. If the error reduced it would also be known as linearity error. To adjust this error the face of the aneroid sphygmanometer must be removed. It is necessary to adjust the internal pivot point. Take great care as the screws are very small and will strip easily. Also take care as a very small adjustment will make a very great difference to the readings and the linearity. After each adjustment of the pivot it will be necessary to rezero the gauge before further testing. This is required occasionally, usually as result of the gauge being dropped. It is best done by someone who has experience in aneroid blood pressure units. It is, however a skill that may be learned by anyone willing to be patient and taking care in their work. On some units it may be possible

to adjust the linearity in the following manner. Each adjustment should be made in very small amounts followed by a check to assess the effect.

- Start by making sure the pointer is on the zero mark.
- Remove the glass, then carefully remove the pointer and lift off the dial. You should now see the triangle with concave sides, on one side of which is a pin.
- In order to correct a non-linear error bend this pin very slightly away or towards the side of the triangle, replace the dial and pointer and run the calibration check again. Repeat this operation until the error has gone.
- When correcting a linear error bend this pin very slightly along the line of the triangle side.
- Run the calibration check again and keep adjusting until the error is gone.
- Should the cover glass be broken it will be necessary to obtain a replacement. Do not return an aneroid sphygmanometer to service without the cover. The unit movement will be damaged and patient BP will be incorrect. This may lead to an incorrect diagnosis or treatment.
- After making the adjustments apply a little watch oil to the bearing points.

3.1.3.3 Procedure;

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