

BLOOD PRESSURE

1. Background and Rationale

Blood pressure measurements will be taken to document baseline blood pressure. Also, the seated blood pressure measurements will be used for the pulse wave velocity test, and the standing blood pressure measurement will be used for the long distance corridor walk exam. In addition, individuals with extremely high levels of blood pressure will be excluded from quadriceps strength and endurance testing and referred for medical care according to the protocol for referrals.

2. Equipment and Supplies

- conventional mercury sphygmomanometer.
- blood pressure cuffs (small, regular, large and thigh cuffs).
- stethoscope: standard stethoscope and ear pieces with bell, tubing to be maximum of 14 inches long.
- double-headed stethoscope (for training only)
- tape measure
- eyebrow pencil
- chair with back support

2.1 Maintenance of Blood Pressure Equipment

Daily:

- 1) Check the sphygmomanometer for correct zero. Place the instrument flat on the table and disconnect the inflation system. With eyes level with the zero line, assure the top of the meniscus is on the zero line.
- 2) Check the shape of the meniscus--it should be a smooth, well-defined curve.

Monthly:

- 1) Check that the mercury rises easily in the tubing and that the mercury column does not bounce noticeably when the valve is closed.
- 2) Check for cracks in the glass tube.

- 3) Check the cap at the top of the calibrated glass tube to make sure it is securely in place.
- 4) Check for spilled mercury in the manometer case.
- 5) Check the cuffs, pressure bulb, and manometer and stethoscope tubing for cracks or tears.
- 6) Check the pressure control valve for sticks or leaks.
- 7) Check the stethoscope diaphragm for cracks.
- 8) Make sure when you close the manometer case that:
 - the manometer tubing is connected and the thumb valve is closed
 - the manometer case is stored on its right side so that the mercury will flow back into the reservoir.
- 9) Never attempt to repair the equipment yourself. Send the instrument for repair if any of the above checks reveal a problem.
- 10) Check the sphygmomanometer for air leaks. Roll the cuff around a plastic bottle or tin can and secure in place. Close the valve on the Air-Flo system and inflate the instrument until the mercury rises to 240 mm Hg. Close the valve. The mercury column should remain stable. If the column continues to fall, there is an air leak and the system should be re-inflated until the column rises to 200 mmHg. Pinch the tubing at various locations to localize the area of the leak, then replace the leaking tubing, cuff, or valve.

General:

With time, the mercury will become dirty and an oxide layer will be deposited on the inside of the glass tube. Do not attempt to clean the glass column with a pipe cleaner, as hazardous levels of mercury aerosol will be produced. Have your QC supervisor send the instrument to your local supplier for repair.

Since mercury is a hazardous, toxic substance, all maintenance and proper disposal procedures must be performed carefully (consult your local institution for guidelines). Do not perform any maintenance procedures that will expose mercury to air. A manometer specialist with expertise in handling toxic substances should be contacted to add or withdraw mercury from the instrument.

Check the blood pressure cuffs on a monthly basis to assure all sizes of cuffs are available. Document the monthly checks of the sphygmomanometer on your Quality Assurance (QA) Equipment Log Form.

Inspect the tape used to measure arm circumference for damage or wear twice a year and record these checks on the QA Equipment Log Form.

3. Safety Issues and Exclusions

None.

4. Participant and Exam Room Preparation

Caffeine (from coffee, tea, or soda), eating, heavy physical activity, smoking and alcohol should be proscribed for 30 minutes prior to recording the blood pressure.

4.1 Arm Circumference Measurement

Check to see if ankle-arm blood pressure has already been taken. Use the same cuff size for the arm. If the ankle-arm blood pressure has not already been taken, please follow the instructions below to measure the participant's right arm.

Measure the participant's right arm to determine the appropriate cuff size before allowing the participant to rest. If the participant's right arm is injured or missing, use the left arm for the arm circumference and blood pressure measurement.

Use the following procedures to measure the participant's arm and determine the appropriate cuff size:

- Proper measurement requires that the participant's arm is bare to the shoulder. The participant will be wearing a gown or loose-fitting top provided by the clinic.
- Request the participant to stand, bend the elbow, and put the forearm straight across the chest. The upper arm should be at a 90 degree angle to the lower arm.
- Measure arm length from the bony prominence of the shoulder girdle (acromion) to the tip of the elbow using a tape measure.
- Mark the midpoint on the dorsal (back) surface of the arm.
- Ask the participant to relax their arm along the side of the body.

- Draw the tape measure horizontally around the arm at the midpoint mark, but do not indent the skin.
- Use the measurement to determine the correct cuff size.

Do not use the markings on the blood pressure cuff for reference. Instead, use the following criteria for determining the appropriate cuff size for the participant:

<u>Arm Circumference (cm/in.)</u>	<u>Cuff's Bladder Size (cm)*</u>
16.0 - 22.5 cm (6.4 - 9.0 in)	small cuff (9.0 cm)
22.6 - 30.0 cm (9.1 - 12.0 in)	regular cuff (12.0 cm)
30.1 - 37.5 cm (12.1 - 15.0 in)	large cuff (15.0 cm)
37.6 - 43.7 cm (15.1 - 17.5 in)	thigh cuff (17.5 cm)

Keep the above chart of arm circumference measurements and corresponding cuff sizes readily available for easy reference.

5. Detailed measurement procedures

In measuring the participant's blood pressure, the participant should rest for approximately five minutes with their feet flat on the floor and legs uncrossed. The maximum inflation level should be determined and two blood pressure readings obtained. For simplicity, all blood pressure measurements will be made on the participant's right arm. Where this is not feasible, the left arm should be used and the exception noted on the comments section of the form. After the baseline measure, the same arm will be used (if possible) throughout the study.

5.1 Application of the Cuff

- Ensure that the participant is seated comfortably in a chair with back supported and both feet are flat on the floor.
- Make sure that the participant's arm is resting on the table at a 90 degree angle with the palm facing up.
- Palpate the brachial artery.
- Mark the brachial artery with an eyebrow pencil.
- Place the appropriate-sized cuff around the upper right arm, approximately at heart level, with the participant's palm facing upward (the participant may rest

their forearm and elbow on a table or arm of the chair). Place the lower edge of the cuff with its tubing connections about one inch above the natural crease across the inner aspect of the elbow.

- Wrap the cuff snugly about the arm, with the inflatable inner bladder centered over the area of the brachial artery. The brachial artery is usually found at the crease of the arm, slightly toward the body. Secure the wrapped cuff firmly by applying pressure to the locking fabric fastener over the area that it overlaps the cuff. You should be able to insert two fingers under the cuff.
- If it is not feasible to measure blood pressure using the right arm, the left arm may be used. The change in arm and the reason for the change should be noted on the comments section of the form.

5.2 Rest Period

Ask the participant to sit with both feet flat on the floor and to rest without smoking or talking for five minutes before measuring their blood pressure. Instruct the participant on the correct posture with the back supported and both feet flat on the floor. The work station should be free of excessive noise and the participant should not be interviewed nor asked to read anything at this time. After the seated blood pressure measurements are taken, the participant should be instructed to quietly stand for one minute before the standing blood pressure is taken.

5.3 Determining the Maximal Inflation Level (MIL)

5.3.1 Auscultatory Gap

An auscultatory gap is the fading or disappearance of sound after the first sounds are heard. The sound then reappears at a level well above the diastolic pressure. The radial pulse can still be felt during the silent phase and the gap usually occurs between Phase I and II. This phenomenon is seen more frequently in older participants.

This means that in an adult with an auscultatory gap, the real systolic pressure may be missed and read as a much lower BP. For example:

Real systolic is 172 but sounds fade at:

168 and reappear at
152 and disappear at
98.

If the correct procedure (inflating to MIL) for BP measurement is not used, this participant's BP may be read as 152/98 instead of 172/98. The only way to avoid this error is to obtain the MIL before BP measurement.

Determine the pressure to which to inflate the cuff for the measurement of the systolic blood pressure. This assures that the cuff pressure at the start of the reading exceeds the systolic blood pressure and allows you to hear the first Korotkoff sound. The procedures for determining maximal inflation level are as follows:

- Attach the cuff tubing to the conventional mercury sphygmomanometer.
- Palpate the radial pulse (if the radial pulse is difficult to palpate, the brachial pulse may be used).
- Inflate the cuff to 70 mmHg. Then increase by 10 mmHg increments until the radial pulse is no longer felt (palpated systolic).
- Deflate the cuff quickly and completely.
- Inflate the cuff to 30 mmHg above the palpated systolic pressure for all subsequent readings.
- Repeat the MIL if the first attempt was unsatisfactory or you have had to readjust the cuff after measuring the MIL. Wait 30 seconds before making a second attempt if the first is unsatisfactory. If the second attempt is unsatisfactory, terminate the procedure and note the problem on the form.
- If the radial pulse is still felt at a level of 270 mm Hg or higher (which means that the MIL is 30 mm Hg higher) repeat the MIL. If the MIL is still 300 mm Hg, terminate the blood pressure measurements and write in "300/MIL" on the form. On the Report of Findings, indicate the blood pressure as 270 palpated, and refer the participant to see their doctor within the next week.

5.4 Performing the Measurement

- Place the ear pieces of the stethoscope, with the tips turned forward, into your ears.
- Apply the bell of the stethoscope over the brachial artery with light pressure, ensuring skin contact at all points. Effective use of the bell requires careful palpation of the brachial artery to know exactly where to place the bell. Place the bell just below, but not touching, the cuff or tubing.
- Close the thumb valve and squeeze the bulb, inflating the cuff at a rapid but smooth and continuous rate to the maximal inflation level. *Note:* Your eyes

should be level with the mid-range of the manometer scale and focused on the level to which you will raise the pressure.

- Open the thumb valve very slightly and maintain a constant rate of deflation at no more than 2-3 mm per second, allowing the cuff to deflate. Listen throughout the entire range of deflation, from the maximum pressure past the systolic reading (the pressure where the first regular sound is heard) until 10 mmHg below the level of the diastolic reading (i.e., 10 mmHg below the level where you hear the last regular sound).

The systolic value (Phase I) is the pressure at which you hear the first of two or more knocking sounds in appropriate rhythm. The diastolic sound (Phase V) is the pressure at which you hear the last muffled sound.

- Deflate the cuff fully by separating the tubing and remove the stethoscope ear pieces.
- Record the systolic and diastolic values from the first reading in the spaces provided on the form.
- Hold the participant's arm vertically above their head for a full five seconds to relieve blood pooling.
- Have the participant sit quietly for 30 seconds, then repeat the blood pressure measurement and record the systolic and diastolic values from the second blood pressure measurement on the form.
- Have the participant stand quietly for one minute, then take one standing blood pressure measurement and record the systolic and diastolic values from this measurement on the Blood Pressure Form (p. 13 of the Baseline Clinic Visit Workbook) and on the Long Distance Corridor Walk Data Collection Form (p. 31 of the Baseline Clinic Visit Workbook).

5.5 Criteria for Systolic and Diastolic Blood Pressure

To identify correctly systolic (Phase I) and diastolic (Phase V) Korotkoff values, listen carefully via the stethoscope while reading and interpreting the mercury column.

- The systolic value is the pressure level at which you hear the first of two or more knocking sounds in the appropriate rhythm. *Note:* A single sound heard in isolation (i.e., not in rhythmic sequence) before the first of the rhythmic sounds (systolic) does not alter the interpretation of blood pressure).

- The diastolic value can be identified as the pressure level at which you hear the last of these rhythmic sounds (usually muffled).
- Make the mercury column drop at 2 to 3 mmHg per second, from the maximum inflation pressure until 10 mmHg below that of the last regular sound heard. The control of the deflation rate at 2 to 3 mmHg per second is essential for accurate readings and depends on the handling of the bulb and its control valve.

5.6 Guidelines for Blood Pressure Readings

- Record all readings to the nearest even digit, rounding up (i.e., read any value that appears to fall exactly between the markings on the mercury column to the next higher even marking).
- Make readings at the top of the meniscus, or rounded surface of the mercury columns.
- When the pressure is released too quickly from a high level, a vacuum is formed above the mercury and the meniscus is distorted. Allow a few moments for it to reappear before reading the manometer or doing a repeat measurement.
- Repeat the MIL whenever a systolic blood pressure reading is less than 10 mm mercury from the MIL, or if sounds are heard immediately.
- If a measurement was interrupted, use the following guidelines:
 1. Repeat the MIL only if the cuff was removed or more than five minutes has lapsed between the MIL and the first blood pressure reading or between any two blood pressure readings.
 2. Note on the form in the comments section that the measurement was repeated, and indicate why.
- If the blood pressure sounds are not heard during the first measurement, review your technique, check stethoscope position for loose connections or tubing kinks, and maintain a quiet environment. Relocate the brachial pulse and apply the bell headpiece directly over the pulse point. Take care to wait at least 30 seconds between measurements. Use the procedure to enhance the sounds (see below) and take the second reading, placing the stethoscope in the same position. Note the use of the enhancement procedures in the comments section of the form.

5.7 Procedures to Enhance the Brachial Pulse Sounds

If you are having difficulty hearing the blood pressure sounds, there are three methods that can be used to increase the intensity and loudness of the sounds.

1. Reduce room noise.
2. Instruct the participant to open and close their fist 8 to 10 times. Inflate the cuff and take the BP immediately.
3. Have the participant raise their arm and forearm over their head and make a fist several times for at least 60 seconds. Inflate the cuff while the arm is still overhead, but the hand relaxed, to a level 50 mm Hg above the expected systolic level. Then lower the arm rapidly and measure the blood pressure in the usual manner.

6. Procedures for performing the measurement at home (if applicable).

The same procedures described above may be performed at home.

7. Seated blood pressure alert values/Follow-up/Reporting to participants

- An immediate referral to the participant's primary physician via telephone before the participant leaves the clinic:

systolic blood pressure ≥ 210 , or
diastolic blood pressure ≥ 120

- An urgent referral to the primary care provider (within 1 week):

systolic blood pressure 180-209
diastolic blood pressure 110-119

- Report to primary care provider (within 1 month):

systolic blood pressure 160-179
diastolic blood pressure 100-109

- Report to primary care provider (confirm within 2 months):

systolic blood pressure 140-159
diastolic blood pressure 90-99

- Normal Categories

High normal:

systolic blood pressure 130-139
diastolic blood pressure 85-89

Normal:

systolic blood pressure <130
diastolic blood pressure <85

Seated blood pressure measurements will be given to the participant at the time of the clinic visit. They will receive a printed form with the above referral information and levels, with blanks for recording participant's values. The same information will be included in the final report to participant and participant's physician.

8. Quality assurance

8.1 Training Requirements

Clinical experience with blood pressure measurement is required. In addition, training should include:

- Read and study manual
- Attend Health ABC training session on techniques (or observe administration by experienced examiner)
- Practice on volunteers
- Compare measurements with those made by experienced colleagues (Goal: obtain measurements within ± 2 mm Hg of that observed by a trainer listening with a double-headed stethoscope.)
- Discuss problems and questions with local expert or QC officer

8.2 Certification Requirements

- Complete training requirements
- Explain and demonstrate daily and monthly checks of sphygmomanometer
- Explain procedure if measurement interrupted
- Explain procedure to enhance brachial pulse sounds
- Recite alert values
- Conduct exam on two volunteers while being observed by QC officer listening with double-headed stethoscope

- Performs exam according to protocol as demonstrated on completed QC checklist
- Three simultaneous readings of systolic and diastolic measurements recorded by the staff member agree with those of the QC officer within ± 4 mm Hg, with the average of the three readings within ± 3 mm Hg.

QC reports: Monthly reports of the distribution of final digits for each technician will be reviewed by the QC Officer. Trends toward digit preference will be discussed with the technician without revealing which digit and retraining/recertification may be required.

8.3 Quality Assurance Checklist

- Explains procedure
- Measures for cuff size (or, if ankle-arm blood pressure has already been done, uses same arm cuff size)
- Wraps cuff snugly, centering bladder over brachial artery
- Five minute rest period before measurement
- Determines maximal inflation level
- Palpates brachial artery
- Inflates rapidly to maximal inflation level
- Places bell on brachial pulse
- Deflates cuff 2-3 mm Hg per second
- First and fifth phase correctly identified (verified with double stethoscope)
- Standing blood pressure measurement taken after one minute standing rest period
- Records reading and disconnects tubes
- Reviews forms for completeness
- Correctly completes forms
- Tells participant BP reading and refers as indicated
- Maintenance log up to date

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9. References

Acknowledgments:

Women's Health Initiative Operations Manual. Volume 2, Section 9.2: Blood Pressure. 8/30/95.

WHAS Operations Manual. Section 3.5 Blood Pressure Measurements. 6/18/93.