

ANKLE-ARM BLOOD PRESSURE

1. Background and Rationale

The ankle-arm index (AAI) is the ratio of the ankle to arm systolic blood pressure. It is reduced to less than 1.0 when there is obstruction to blood flow in legs. The AAI is a non-invasive measure of atherosclerotic obstruction in the legs and is a general marker of atherosclerotic burden. The degree of subclinical and clinical atherosclerosis is hypothesized to be related to the decline in lean mass and increase in abdominal adiposity with age. AAI is associated with atherosclerotic disease in other vascular beds and predicts subsequent mortality and cardiovascular mortality. The impact of subclinical cardiovascular disease on loss of bone and muscle mass and subsequent disability is not clear.

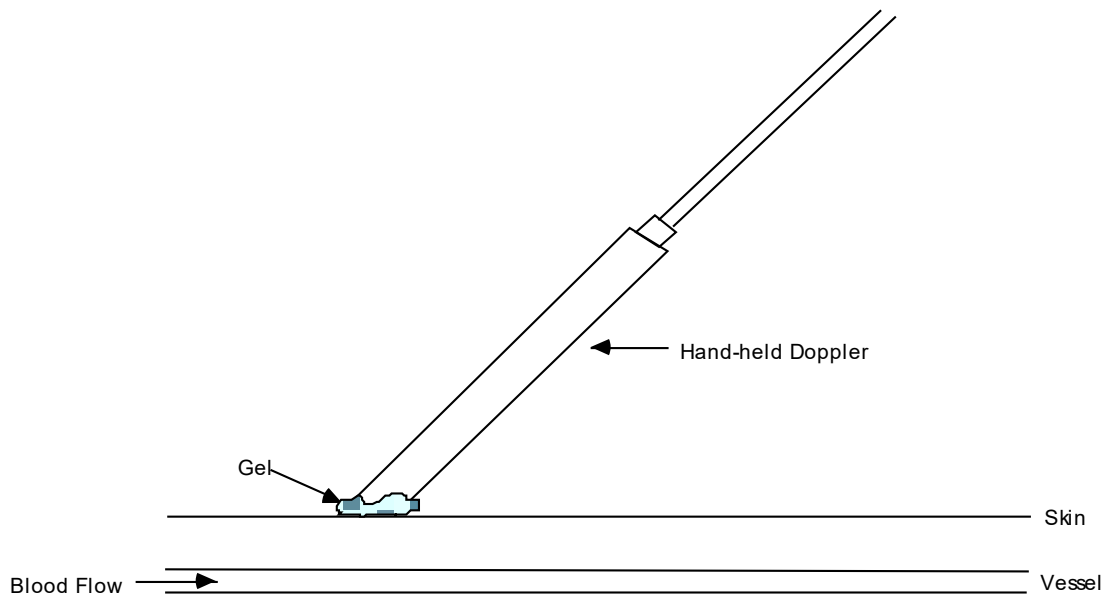
2. Equipment and Supplies

- hand-held 8 megahertz Doppler probe with built-in speaker
- supply of 9 volt alkaline batteries
- Doppler conducting jelly (Aquasonic Ultrasound gel is recommended)
- BpTru digital sphygmomanometers (model BMP-300)
- blood pressure cuffs (large cuff, extra large cuff, 3 small cuffs, 3 regular cuffs)
Please note that a child cuff is also available for purchase.
- black eyeliner pencil (or hydromarker)
- tissues to remove conducting jelly
- disposable socks / slippers

2.1 Use

Using the Doppler. Push button in to turn on and gradually turn the volume up. Now place the probe over the artery (brachial or posterior tibial).

The frequency used is 8 Megahertz (vibrations of 8 million times per second). In order to hear the signal above background noise, the instrument must be pushed in toward the artery. Angling the beam upstream improves the signal. For deeper vessels, the unit will have to be tilted back toward perpendicular, but NOTE: the instrument works poorly or not at all if held fully perpendicular to the flow. It must always be angled into and IN LINE with the flow. Please see figure below.



In some places along the posterior tibial artery, there is anatomical hiding of the vessel by muscle or tendons. Move up or down the vessel a little to find the best signal above background noise.

The purpose of the Doppler is to determine that blood is or is not flowing under the cuff. For correct interpretation, the probe **MUST** be centered directly over the artery and must not be moved while inflating the cuff.

Please note that the Doppler unit turns itself off after 5 minutes automatically. This may occur in the middle of a measurement.

2.2 Maintenance

KEY POINT: Use only ultrasound gel

The probe. The probe consists of two crystals; one for transmitting the ultrasound waves and the other for receiving the reflected waves. If either crystal is damaged, the probe will not work properly or will not work at all. The crystals are covered by epoxy resin. This resin is attacked by any gel or liquid containing the chloride ion. Therefore, **NEVER** use ECG paste or cream as the contact medium between the skin and the crystals. Use **AQUASONIC** or any gel made for ultrasonic physical therapy equipment. In an emergency use any surgical jelly or lubricant, even Vaseline or mineral oil. Remove the gel after use with a soft tissue. If the probe has dried gel on it, wash it off under running water. Do **NOT** scrape off the gel because this may damage the epoxy coating. Do **NOT** autoclave the probe. Gas sterilization is OK.

KEY POINT: To preserve battery, turn off unit immediately after measurements

The battery. As the battery runs down, the signal will get weaker to the point where the instrument just doesn't work. Most batteries run down because the instrument has been left turned on. It takes less than a minute to make a blood pressure measurement. Turn the unit off immediately after removing it from the skin. Use an alkaline-type replacement 9-volt transistor

radio battery. Three screws hold the battery in the case. After loosening or removing the screws, gently lift up the back to replace the battery.

Strange noises from the Doppler. On occasion there are unusual noises from the Doppler that do not indicate a problem with the Doppler. The normal sound will become obvious with experience in performing this test. Following are some common complaints and their causes.

1. Popping noises when the probe is first placed on the skin. Scratchy sound at first. Cause: bubbles in the gel that are moving and/or popping. Also hair movement can cause noise. Remedy: Use a new glob of gel that looks clear, push down enough so hair is immobilized, and just wait a few seconds for things to settle down. If the noise isn't there when the probe is clean (no gel) and suspended in the air, the Doppler and/or probe are probably not at fault.
2. Bad static when the dry probe is moved in the air. Cause: a loose connector where the probe connects to the instrument, a broken shield wire in the cable either at the connector or as it comes out of the probe. This can be diagnosed by wiggling the wire or connectors gently. There is NORMALLY some static generated when the cable is flexed, but it isn't severe. Remedy: QC Officer will arrange to replace probe or get connectors fixed.
3. High-pitched tone. Cause: radio interference from a mobile service, police station nearby, even another Doppler working nearby. Usually occurs near large open windows, rarely in the center of the building. Remedy: Move to another room.
4. Howling noise when the probe with gel on it is held or laid on a table. Cause: acoustic feedback through the probe acting as a microphone. If it doesn't occur without gel on the probe, everything is OK.

3. Safety Issues and Exclusions

All participants enrolled in Mr.OS are eligible for ankle-arm index measurement with the following exceptions:

- persons with open wounds including venous stasis ulcers, rashes, or any open wound
- persons with bilateral amputations

These are recorded as "missing data." See MrOS Ankle-arm Blood Pressure TELEform.

Some participants will have rigid arteries in the legs and the arteries cannot be occluded before the dial reads 300 mmHg. It is possible to find this in only one leg. This should be recorded as "unable to occlude."

The participants are being asked to lie flat or semi-recumbent. Flat or semi-recumbent is defined as the trunk being raised no more than 45 degrees from the surface of the examining table. If the participant is unable to lie at 45 degrees or less, they are excluded. Please record this on the TELEform.

4. Participant and Exam Room Preparation

Ankle-arm blood pressure should be obtained after the resting blood pressure is obtained.

- Ask the participant to remove their shoes, socks and stockings so that the ankles are bare to mid-calf, if this has not been done already. Disposable socks / slippers can be used to keep participant comfortable while waiting for the test to be done.
- Remove the sleeve of the right arm. Measure the arm to determine which cuff size should be used.
- Lay the participant on the examining table with the right side toward the observer and the feet at the free end of the table. Keep the participant recumbent or semi-recumbent for at least five minutes before measuring blood pressure.

Application of Cuffs

- Place three blood pressure cuffs on the participant:

1) Place one cuff on the right arm.

Note: Use the same cuff size that was used for the resting blood pressure measurement. Or use directions below:

To determine the correct cuff size for the blood pressure measurement, use the following procedures:

- 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 his arm along the side of his body.
- Draw the tape measure horizontally around the arm at the midpoint mark, but do not indent the skin.

- Use the measurement to determine 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> |
|-----------------------------------|----------------------------------|
| 13.0 – 18.0 cm | Child cuff (6.5 x 12.5 cm) |
| 18.1 – 26.0 cm | Small cuff (8.9 x 17.1 cm) |
| 26.1 - 32.0 cm | Regular cuff (12 x 22.9 cm) |
| 32.1 – 41.0 cm | Large cuff (15.2 x 33 cm) |
| 41.1 – 52.0 cm | Extra-Large cuff (17.8 x35.6 cm) |

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

If the above listed cuff sizes do not appear to fit a participant, you may use the smaller size cuff as long as the arm circumference falls within the reference values printed directly on the cuff. Please mark the cuff size used on the TELEform.

- 2) Place one standard adult size cuff on the right ankle.
 - 3) Place one standard adult size cuff on the left ankle.
- 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.
 - Apply the ankle cuffs with the midpoint of the bladder over the posterior tibial artery, with the lower end of the bladder approximately 3 cm above the medial malleolus. Rarely, the velcro will not hold due to the ankles being very thin or large. In these cases use small, pediatric or large adult cuffs.
 - Apply ultrasound gel on each limb over the artery now.

5. Detailed Measurement Procedures

5.1 Determining the Maximal Inflation Level (MIL)

The maximal inflation level will be automatically determined by the BpTru manometer for each extremity.

- During the arm measurement, if the MIL is 300 mmHg or higher, terminate the blood pressure measurements and indicate this on the Ankle-arm blood pressure TELEform. Refer the participant to see their doctor based on the blood pressure taken with BpTru monitor. The Doppler will always be higher.

5.2 Performing the Measurement

5.2.1 Right Arm Systolic Blood Pressure Measurement

- Attach the cuff tubing to the manometer.
- Turn unit on.
- Locate the brachial artery by palpation. If you need to, you can also locate the brachial artery by using the Doppler.
- Apply more ultrasound jelly over brachial artery, if needed.
- Sit next to the participant's right arm
- Locate brachial artery using Doppler.
- Measure the systolic blood pressure using the Doppler:
 1. Press the start button on the BpTru
 2. The BpTru will deflate at 4 mmHG per second.
 3. Press the stop button 10mmHG below the appearance of systolic pressure
- Deflate the cuff quickly and completely.
- Record systolic blood pressure in space provided for right brachial on form.

Ankle Systolic Blood Pressure Measurement: Move to the end of the table.

5.2.2 Right Ankle Systolic Blood Pressure Measurement

- Connect right ankle cuff to the manometer.
- Locate the posterior tibial artery by palpation.
- Apply more ultrasound jelly over posterior tibial artery, if needed.
- Measure the systolic blood pressure using the Doppler:
 1. Press the start button on the BpTru
 2. The BpTru will deflate at 4 mmHG per second.

3. Pres the stop button 10mmHG below the appearance of systolic pressure

- Deflate cuff quickly and completely.
- Record the systolic value from the first reading in the space provided for right posterior tibial on the form.

5.2.3 Left Ankle Systolic Blood Pressure Measurement

- Connect left ankle cuff to the manometer.
- Repeat systolic blood pressure measurement as for right leg.
- Record the systolic value from the first reading in the spaces provided for left posterior tibial on the form.

5.2.4 Repeating the Ankle-Arm

- Repeat the sequence in the reverse order:
 - left ankle
 - right ankle
 - right arm
- Review the form for completeness.
- Remove cuffs and conducting jelly.

5.3 Tips for the Ankle-Arm Measurements

- Mark the location of maximal pulse or Doppler signal on the brachial artery and both posterior and tibial arteries with an eyeliner pencil (or hydromarker) to improve the speed and accuracy of localizing them the second time and to help maintain position.
- Hold the Doppler pen absolutely still while inflating and deflating the cuff; moving a few millimeters will lose the pulse.
- Always use enough jelly to ensure good contact.
- The systolic value is the pressure level at which you hear the first of two or more swishing 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).
- If the automated device continues to pump the cuff during one of blood pressure measurements (either arm or ankles) and potentially misses the maximum inflation level or it is obvious that the participant is experiencing much discomfort, please manually stop the measurement. Let the participant rest for at least 1 minute and repeat the attempt. If after 2 attempts on the same ankle or arm the reading is not obtainable, please mark that

the blood pressure measurement was not obtained on the data collection form. If two failed attempts are made on the first measurement, do not attempt the 2nd measurement on that arm or ankle.

- If an error message is displayed for any of the measures, it should be repeated. Allow for 1 minute rest before starting another measurement. If an error message is displayed after the second attempt, please mark on the TELEform that there was an error message for that particular value and move on to the next location. If you get 2 error messages for a given location the first time around, the measurement should not be attempted when going back through for the second measurement on that arm or ankle. Please note that even if you get an error message for one of the leg measurements, you should still mark the corresponding question on the bottom of the TELEform about the left or right leg measurement being obtained as 'Yes'. Only mark 'NO' if there was a different reason the measure could not be obtained.

5.4 Calibration of the blood pressure equipment

Follow the manufacture's recommendations for the calibration of the BpTru.

5.5 Calculation of Ankle-Arm Blood Pressure Ratio

Clinics may choose to provide the ankle-arm blood pressure ratio as part of the participants' results from Visit 3. You may contact the CC if you would like this value generated for your site. In general, it could up to 8 weeks from the time data was received for this to be available. The calculations are made in the manner described below:

- 1) The average brachial systolic blood pressure is determined
(Brachial Measurement #1 + Brachial Measurement #2) / 2
- 2) The average right posterior tibial systolic blood pressure is determined
(Right Posterior Tibial Measurement #1 + Right Posterior Tibial Measurement #2) / 2
- 3) The average left posterior tibial systolic blood pressure is determined (Left Posterior Tibial Measurement #1 + Left Posterior Tibial Measurement #2) / 2
- 4) Ankle-Arm Blood Pressure Ratio for Right Side:
Measurement 1 = (average right posterior tibial / average brachial) x 100
- 5) Ankle-Arm Blood Pressure Ratio for Left Side:
Measurement 2 = (average left posterior tibial / average brachial) x 100

6. Alert Values/Follow-up/Reporting to Participants

This is a screening test for atherosclerotic obstruction in the lower legs. Sites can choose to provide participants a report of the ankle-arm index in each leg as a part of a report of study results, with a general clinical interpretation:

“The ratio of ankle to arm systolic blood pressure is one measure of blood flow in the legs. The normal ratio is usually greater than 90%.” At this time, reports will not be provided directly to the participant’s physician. If participant scores 90% or below, it is OK to tell the participant that their value was “on the low side” and suggest that they consider providing the results to their physician for further evaluation. If requested, a good reference is as follows:

“Newman AB; Siscovick DS; Manolio TA; Polak J; Fried LP; Borhani NO; Wolfson SK. Ankle-arm index as a marker of atherosclerosis in the Cardiovascular Health Study. Cardiovascular Heart Study (CHS) Collaborative Research Group. *Circulation*, 1993 Sep, 88(3):837-45.”

Staff Alert:

An extremely low AAI could indicate severely restricted blood flow to the leg, however a clinic intervention to restore flow would only be done if there were severe symptoms (i.e. severe pain at rest, ulceration or gangrene). Staff are not expected to be able to diagnose these conditions but should encourage participants who ask them about any symptoms to consult their physician.

8. Quality Assurance

8.1 Training Requirements

Staff performing the ankle-arm index measurements should be research technicians or clinicians *previously* trained in taking research blood pressure measurements. In addition, training should include:

- Read and study manual
- Attend Mr.OS training session on techniques (or observe administration by experienced examiner)
- Practice on volunteers
- Discuss problems and questions with local expert or QC officer

8.2 Certification Requirements

- Complete training requirements
- Recite exclusion criteria
- Conduct exam on two volunteers
- Performs exam according to protocol as demonstrated on completed QC checklist

8.3 Quality Assurance Checklist

Right Arm Systolic BP Measurement

- Explains procedure
- Uses cuff size determined during blood pressure measurement, or, if blood pressure has not yet been taken, determines cuff size using directions in blood pressure chapter
- Five minute rest period before measurement
- Turns unit on
- Palpates brachial artery
- Applies ultrasound jelly over brachial artery
- Locates brachial artery using Doppler
- Measures the systolic blood pressure using the Doppler
 - Presses the stop button 10mmHG below the appearance of the systolic pressure
- Deflates cuff quickly and completely.

Right Ankle:

- Places blood pressure cuff (appropriate size) on right ankle.
- Locates posterior tibial artery by palpation
- Applies ultrasound jelly over posterior tibial artery
- Locates posterior artery using Doppler
- Measures the systolic blood pressure using the Doppler
 - Presses the stop button 10mmHG below the appearance of the systolic pressure
- Deflates cuff quickly and completely.

Left Ankle:

- Places blood pressure cuff (appropriate size) on right ankle.
- Locates posterior tibial artery by palpation
- Applies ultrasound jelly over posterior tibial artery
- Locates posterior artery using Doppler
- Measures the systolic blood pressure using the Doppler
 - Presses the stop button 10mmHG below the appearance of the systolic pressure
- Deflates cuff quickly and completely.

Repeat of Ankle-Arm Measurements:

- Repeats sequence of measures in reverse order:
 - Left ankle
 - Right ankle
 - Right arm

Completion:

- Removes cuffs and conducting jelly
- Turns Doppler unit off immediately
- Reviews form for completeness
- Correctly completes form

8.4 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.

9. References

1. Newman AB; Siscovick DS; Manolio TA; Polak J; Fried LP; Borhani NO; Wolfson SK. Ankle-arm index as a marker of atherosclerosis in the Cardiovascular Health Study. Cardiovascular Heart Study (CHS) Collaborative Research Group. *Circulation*, 1993 Sep, 88(3):837-45.

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