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.

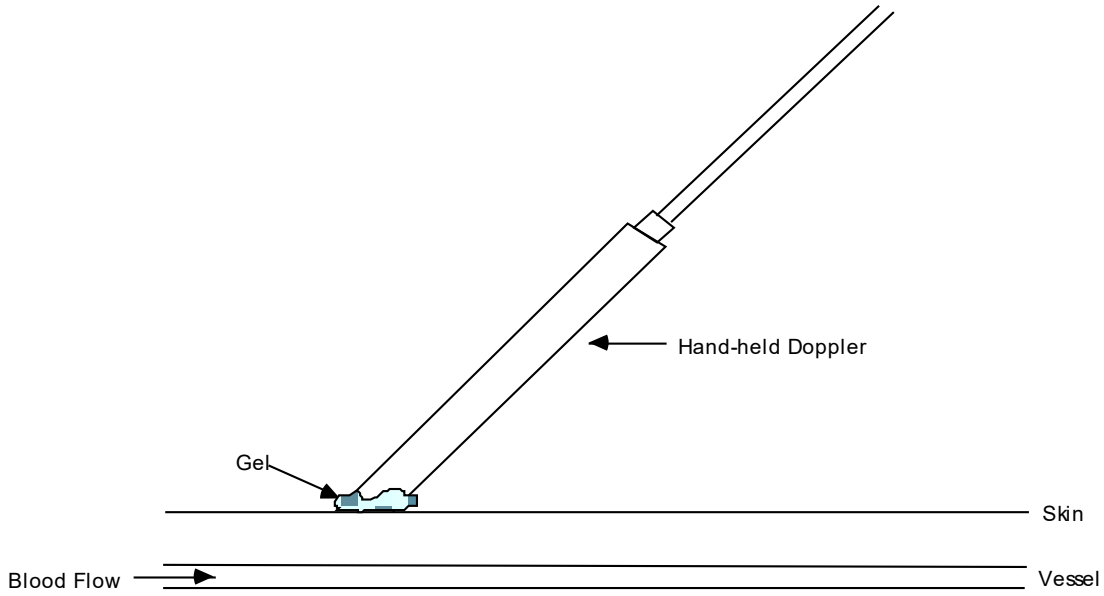
2. Equipment and Supplies

- hand-held 8 megahertz Doppler probe with built-in speaker
- supply of 9 volt alkaline batteries
- Doppler conducting jelly (Aquasonic Ultrasound gel is recommended)
- portable standard mercury column sphygmomanometers
- blood pressure cuffs (1 large cuff, 1 thigh cuff, 3 small (pediatric) cuffs, 3 regular cuffs)
- black eyeliner pencil
- 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 data entry form.

Some participants will have rigid arteries in the legs and the arteries cannot be occluded before the mercury column reaches 300 mmHg. It is possible to find this in only one leg. This should be recorded as "unable to reach occlusion blood pressure."

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 form.

4. Participant and Exam Room Preparation

- 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.

  2) 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:

Arm circumference (cm/in.)	Cuff's Bladder Size (cm)
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.

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 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)

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 maximal inflation level should be measured specifically for the ankle-arm index measurement, using the Doppler, independently from it's measurement for the regular blood pressure measurement. The procedures for determining maximal inflation level are as follows:

- Attach the cuff tubing on the arm to the conventional mercury sphygmomanometer.

- Locate the brachial pulse with the Doppler.

- Inflate the cuff until the brachial pulse is no longer heard.

- Deflate the cuff quickly and completely.

- Inflate the cuff to 30 mmHg above the Doppler 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 brachial pulse is still heard at a level of 270 mmHg or higher (which means that the MIL is 30 mmHg or higher) repeat the MIL. If the MIL is still 300 mmHg, terminate the blood pressure measurements and write in "300/MIL" on the form. On the Report of Findings, indicate the blood pressure at the level heard. Refer the participant to see their doctor based on the blood pressure taken with a stethoscope. The Doppler will always be higher.

5.2 Performing the Measurement

Wait 30 seconds after determining the maximal inflation level and follow the steps below for performing the blood pressure 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:
    - Inflate the cuff quickly to the maximal inflation level.
    - Deflate at 2 to 3 mmHg per second to 10 mmHg 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 and place the manometer between the participant's ankles.

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: Inflate the cuff quickly to the maximum inflation level.
- If sounds are still present, continue to inflate 30 mmHg at a time, until the sound is obliterated.
- Deflate at 2 to 3 mmHg per second to 10 mmHg 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 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).

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.

5.4 Calculation of Ankle-Arm Blood Pressure Ratio

The ankle-arm blood pressure ratio results will be included in the Baseline Visit Participant Report and Baseline Visit Physician Report sent out approximately 8 weeks after the baseline clinic visit. 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. Procedures for Performing the Measurement at Home

The same procedures described above may be performed at home with the proper equipment.

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

This is a screening test for atherosclerotic obstruction in the lower legs. Participants will receive 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."

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
- Compare measurements with those made by experienced colleagues (Goal: obtain measurements within ± 2 mm Hg of that observed by a trainer)
- 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 while being observed by QC officer listening with Doppler
- Performs exam according to protocol as demonstrated on completed QC checklist
- Three simultaneous readings of systolic 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.

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
- Determines maximal inflation level
- 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 and standard manometer:
- Inflates cuff quickly to maximal inflation level
- Deflates at 2 to 3 mmHg/second to 10 mmHg below the appearance of systolic pressure.
- Deflates cuff quickly and completely.

Ankle Systolic BP Measurement

- Moves to the end of the table and places manometer between participant's ankles.

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 and standard manometer:
  Inflates cuff quickly to maximal inflation level
  Inflates further by 30 mmHg increments if sounds are still present.
  Deflates at 2 to 3 mmHg/second to 10 mmHg below the appearance of systolic pressure.
  Deflates cuff quickly and completely.

Left Ankle:

- Places blood pressure cuff (standard size) on left 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 and standard manometer:
  Inflates cuff quickly to maximal inflation level
  Inflates further by 30 mmHg increments if sounds are still present.
  Deflates at 2 to 3 mmHg/second to 10 mmHg below the appearance of 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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