

SEATED BLOOD PRESSURE AND HEART RATE MEASUREMENT (Year 3)

1 Background and Purpose

Level of blood pressures is subject to biologic and observer variations, the latter being due to errors in measurement. The purpose of a specific protocol for the measurement of BP and a stringent certification procedure for technicians who measure BP in CHS is to minimize error in measurement.

2 Definitions and Alerts

The seated BP reading for CHS is an average of the two systolic and diastolic BP's calculated by computer. When either Blood Pressure reading is elevated, it will trigger an "alert" and subsequent participant/ physician notification.

2.1 The 1988 Report of the Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure defines categories of BP and recommend follow-up according to the following criteria:

2.1.1 Classification of BP in Adults Aged 18 Years or Older*

BP Range, mm Hg Category**

Diastolic BP

< 85	Normal BP
85-89	High-Normal BP
90-104	Mild Hypertension
105-114	Moderate Hypertension
≥ 115	Severe Hypertension

Systolic BP, when Diastolic BP < 90 mm Hg:

< 140	Normal BP
140-159	Borderline isolated systolic hypertension
≥ 160	Isolated systolic hypertension

* Classification based on the average of two or more readings on two or more occasions. BP indicates blood pressure; DBP diastolic blood pressure; and SBP, systolic blood pressure.

** A classification of borderline isolated systolic hypertension (SBP, 140 to 159 mm Hg) or isolated systolic hypertension (SBP, ≥ 160 mm Hg) takes precedence over high-normal BP (DBP 85 to 89 mm Hg) when both occur in the same person. High-normal BP (DBP, 85 to 89 mm Hg) takes precedence over a classification of

normal BP (SBP, < 140 mm Hg) when both occur in the same person.

2.1.2 Follow-up Criteria for Initial BP Measurement for Adults Aged 18 Years or Older*

<u>BP Range, mm Hg</u>	<u>Recommended Follow-up</u>
Diastolic BP	
< 85	Recheck within 2 yr
85-89	Recheck within 1 yr
90-104	Confirm within 2 mo
105-114	Evaluate or refer promptly to source of care within 1 week
≥ 115	Evaluate or refer immediately to source of care
Systolic BP, when DBP < 90 mm Hg	
< 140	Recheck within 2 yr
140-199	Confirm within 2 mo
200-219	Evaluate or refer promptly to source of care within 1 week
≥ 220	Evaluate or refer immediately to source of care

* When recommendations for follow-up of DBP and SBP are different, the shorter recommended time for recheck and referral should take precedence.

2.1.3 Alert levels requiring IMMEDIATE referral are:

Diastolic BP ≥ 115
Systolic BP ≥ 220

2.1.4 URGENT alert levels requiring referral within the week are:

Diastolic BP = 105-114
Systolic BP = 200-219

2.1.5 Alert levels requiring ROUTINE physician notification are:

BP ≥ 140/90 requires follow-up within two months time, and therefore we recommend physician notification for systolic or diastolic BP above these levels.

2.2 Blood Pressure Measurement

In order to investigate differences between blood pressure measurements using the random zero and standard sphygmomanometers, participants who return for the Surveillance Clinic Visit will have blood pressure measurements taken using both a

Hawksley random-zero sphygmomanometer and a conventional mercury sphygmomanometer.

2.2.1 Conventional Mercury Sphygmomanometer

The design and operation of the conventional mercury sphygmomanometer are based upon the combined principles of compression of the brachial artery under an elastic, inflatable cuff; and direct registration of pressure levels by a mercury manometer. The observer inflates the cuff, listens for the first- (systolic) and the last (diastolic) Korotkoff sounds, reads the mercury level in the column, deflates the cuff, and records the readings.

Once the cuff and device are connected as required for determination of the maximal inflation level, the steps in measurement with the conventional device are as follows:

- Wait at least 30 seconds after complete deflation of the cuff, following any preceding inflation.
 - Hold the arm as close to vertical as possible for a full 5 seconds.
 - Wait at least 25 seconds before proceeding with any additional reading.
- Place the earpieces of the stethoscope, with the tips turned forward, into the ears.
- Apply the bell of the stethoscope over the brachial artery with light pressure, insuring skin contact at all points. Bell should be placed just below but not touching the cuff or tubing. The brachial artery is usually found at the crease of the arm, slightly toward the body.
- By closing the thumb valve and squeezing the bulb, inflate the cuff at a rapid but smooth, continuous rate to the maximal inflation level.

NOTE: The eyes of the observer should be level with the mid-range of the manometer scale and focused at the level to which the pressure will be raised.

- By opening the thumb valve slightly, and maintaining a constant rate of deflation at approximately 2 mm per second, allow the cuff to deflate, listening 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 mm Hg below the level of the diastolic reading (that is, 10 mm Hg below the level where the last regular sound is heard). NOTE: Phase V diastolic BP is that point at which the last sound is heard.
- Deflate the cuff fully by opening the thumb valve; the stethoscope earpieces are removed from the ears; and the systolic and diastolic readings are entered in the spaces provided on the form.

- Remove the cuff and store the equipment safely after the last reading.

2.2.2 Random-Zero Sphygmomanometer

The Hawksley Random-Zero Sphygmomanometer is a mercury sphygmomanometer, with the same basic principles of operation as the conventional mercury manometer. The essential distinction is a mechanism designed to produce a variable level of mercury in the manometer column when the actual pressure in the cuff is zero. This is accomplished through an adjustable-volume chamber, which is interconnected with the mercury reservoir at one end and the manometer column at the other end.

The adjustment is made by the observer, by spinning an external wheel which contacts and rotates an internal, bevelled cam; the position where the cam comes to rest after spinning determines where the bevelled edge will meet the sliding wall of the mercury chamber; when air pressure is applied through the cuff, the wall is displaced until it rests against the cam, and only the mercury remaining after filling this new volume of the chamber is displaced into the manometer column. A valve controlled by the observer locks the chamber system after the maximum inflation pressure desired has been applied, so that at the end of the reading, and only at the end, the mercury comes to rest at its "randomly" determined zero-pressure level. When this value is subtracted from the recorded readings, the corrected readings give the corresponding actual pressure levels. Thus, by the addition of this mechanism for varying the "zero" level of mercury to the conventional device, the Random-Zero device obscures the true levels of pressure observed until after the uncorrected blood pressure is recorded and the "zero" level is read and subtracted. In this way, some of the recognized difficulties in observer performance are substantially reduced -- primarily, interference by observer bias when readings fall near critical levels of blood pressure.

2.3 Criteria for Systolic and Diastolic Blood Pressure

To correctly identify the 1st-phase (systolic) and 5th-phase (diastolic) Korotkoff values, the observer must listen carefully via the stethoscope while reading and interpreting the mercury column.

- 2.3.1 The systolic value is the pressure level where the first of two or more sounds are heard in appropriate rhythm.
- 2.3.2 The diastolic value can be identified as the pressure level where the last of these rhythmic sounds is heard.
- 2.3.3 The mercury should be made to drop at 2 mm Hg per second, from the maximum pressure until 10 mm Hg below that of the last regular sound heard. The control of the deflation rate is essential for accurate readings and depends on handling of the bulb and its control valve.

NOTE: A single sound heard in isolation (i.e., not in rhythmic sequence) before the first of the rhythmic sounds (systolic) or following the last of the rhythmic sounds (diastolic) does not alter the interpretation of the blood pressure.

2.4 Equipment

- One or two conventional mercury sphygmomanometers
- Three Hawksley Random-Zero Sphygmomanometers
- Two standard stethoscope tubing and earpieces (suggest Litman) with bell, with tubing to be a **maximum** of 14 inches long
- One double headed stethoscope
- BP cuffs in four sizes:
 - 2 large adult cuffs
 - 1 thigh cuff
 - 1 pediatric cuff
 - 2 regular adult cuffs

3 **Methods**

3.1 The blood pressure and heart rate measurements should be done prior to ECG or any other Surveillance Clinic Visit procedure. Following this procedure will provide data comparable to that collected in other studies.

3.2 Conventional Blood Pressure Measurement

The first 10% of participants seen during the Surveillance Clinic Visit will have a conventional blood pressure measurement taken in addition to the random zero measurement. The procedure for this is as follows:

- If the last digit of the participant's ID number is even, a single reading will be performed with a conventional mercury sphygmomanometer prior to two readings with the random zero sphygmomanometer.
- If the last digit of the participant's ID number is odd, the two readings with the random zero sphygmomanometer will be done prior to one measurement with the conventional mercury sphygmomanometer
- After entering the heart rate and technician ID on the computer screen, data screens will appear in the appropriate order; when using paper entry forms, note which measurement was performed first.

3.3 Cuff Size

Proper cuff size must be used to avoid under-or-over-estimation of the correct blood pressure. Cuff Size is the size of the cuff's bladder, not the cloth. A copy of the chart

below should be attached to the sphygmomanometer for easy reference.

The directions for the Arm Measurement Procedure are as follows:

- Participant removes upper garment.
- Participant stands, holding forearm horizontal to the floor.
- Measure arm length from the acromion (bony extremity of the shoulder girdle) to the olecranon (tip of the elbow), using a metric tape.
- Mark the midpoint on the dorsal surface of the arm.
- Participant relaxes arm along side of the body.
- Draw the tape snugly around the arm at the midpoint mark.
NOTE: Keep the tape horizontal. Tape should not indent the skin.
- Use the criteria below for determining cuff size. (Do not use the markings on the blood pressure cuff for reference.)

CUFF SIZE INDICATED BY MEASURED ARM CIRCUMFERENCE

<u>ARM CIRCUMFERENCE (cm)</u>	<u>CUFF'S BLADDER SIZE (cm)*</u>
Up to 5.9	2.5 ("newborn")
6.0 to 15.9	6.5 ("infant")
16.0 to 22.5	9.0 ("child" or "pediatric")
22.6 to 30.0	12.0 ("adult" or "regular")
30.1 to 37.5	15.0 ("large arm")
37.6 to 43.7	17.5 ("thigh")

* Bladder widths shown are at least 40% of the largest corresponding arm circumferences.

- Record the cuff size used on the form.

3.4 Application of Blood Pressure Cuff

- Place the appropriate cuff around the upper right arm so that:
 - The midpoint of the length of the bladder lies over the brachial artery, and
 - The mid-height of the cuff is at heart level.
- Place the lower edge of the cuff, with its tubing connections, about 1 inch above the natural crease across the inner aspect of the elbow.

- Wrap the cuff snugly about the arm, with the palm of the participant's hand turned upward.
- Secure the wrapped cuff firmly by applying pressure to the locking fabric fastener over the area where it is applied to the cuff.
- Do not wrap the cuff too tightly around the arm.

3.5 Determining the Maximal Inflation Level

For each participant determine the maximal inflation level, the pressure to which the cuff is to be inflated for systolic blood pressure measurement. This assures that the cuff pressure at the start of the reading exceeds the systolic blood pressure and thus allows the first Korotkoff sound to be heard.

The procedures for determining Maximal Inflation Level are as follows:

- Attach the cuff tubing to the conventional mercury sphygmomanometer.
- Palpate the radial pulse.
- Inflate the cuff until the radial pulse is no longer felt (palpated systolic) by inflating rapidly to 70 mm Hg, then inflating by 10 mm Hg increments.
- Deflate the cuff quickly and completely.
- Inflate the cuff to 30 mm Hg above the palpated systolic pressure for all readings, plus the maximum zero level.

3.6 Guidelines for Random Zero Readings

- All readings are made to the nearest even digit.
- Any reading which appears to fall exactly between markings on the mercury column should be read to the next higher marking i.e., 2, 4, 6, 8 or 0.
- All readings are made at the top of the meniscus, or rounded surface of the mercury column.
- When the pressure is released 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.

3.7 Heart Rate Measurement

Part of the blood pressure measurement procedure is radial pulse measurement. This measurement serves two purposes: (1) to document the resting heart rate at the time of examination; and (2) to permit detection of gross irregularities of heart rhythm which may affect interpretation of the blood pressure readings.

- Measure pulse on the right arm after the participant has been seated quietly, with both feet flat on the floor, in an erect but comfortable posture, for at least five minutes.
- No smoking is allowed during this period.
- Participant rests the elbow and forearm comfortably on the table.
- Palpate the radial pulse with the palm of the hand turned upward and count for exactly for 30 seconds.
- Record the number of beats in 30 seconds.
- Any marked irregularity observed during this period should be called to the attention of the supervisor, or clinic physician.

3.8 Blood Pressure Readings

Detailed instructions are given below for measuring blood pressure with a Random-Zero sphygmomanometer.

- Connect the cuff to the Random-Zero device.
- Wait at least 30 seconds after complete deflation of the cuff, following any preceding inflation.
 - Hold the arm as close to vertical as possible for a full 5 seconds.
 - Wait at least 25 seconds before proceeding with any additional reading.
- Place the earpieces of the stethoscope, with the tips turned forward, into the ears.
- Ensure that the mercury reservoir lever is in the operating position by turning the control valve on the face of the device to the right, to the position marked "OPEN."
- Turn the wheel (downstroke only) at the right side of the device, by stroking it a few times with the extended fingertips of the right hand.
- Apply the bell of the stethoscope over the brachial artery, just below but not

touching the cuff or tubing. The brachial artery is usually found at the crease of the arm, slightly toward the body.

- Inflate cuff to the previously determined maximal inflation level or to 180 mm Hg, whichever is higher.
- Hold the pressure at this level for 5 seconds (count to 5 slowly), by closing the thumb valve, then turn the control valve to the left, to the position marked "CLOSED."
- Deflate the cuff in the same manner as for the conventional device, (2-3 mm HG per second) by carefully controlling the thumb valve, until the mercury level is 10 mm below the diastolic reading (that is, 10 mm below the level where the last regular sound was heard).
- Open the thumb valve fully and disconnect the tubing from the cuff, allowing the mercury to fall to its "zero" level for this reading.
- Record the uncorrected systolic and diastolic readings.
- Record the "zero" level for the reading.
- By subtraction, calculate and record the actual systolic and diastolic readings in the spaces provided. NOTE: This will be done by the computer.

3.9 Second Readings

- Hold the participants arm as close to vertical as possible for full 5 seconds.
- Wait at least 25 seconds before proceeding with second readings.
- Repeat the steps in Section 7.6 to obtain the second blood pressure readings.

3.10 Data Entry

Data entry will routinely occur on-line concurrently with the process of measuring blood pressure and heart rate. The data entry program has been written to accept the data sequentially in the order as described in "Methods" above.

In the event that the computer is down or unavailable for another reason, a paper form has been designed to collect the necessary information. The form requires that the following variables be reported:

- Question 1 - Time of Day

- Record the time of day (hour:minutes) the participant's blood pressure and heart rate are measured. Standard times are acceptable (e.g. 2:00 PM is 2:00); there is no need to convert the time into military time.

■ Question 2 - Hours Since Last Meal

- Record the number of hours that have elapsed since the participant's last meal. Round up or down to the nearest whole number.

■ Question 3 - Cuff Size

- Record which cuff size was used in taking the blood pressure measurement. A table of the arm circumference in relation to proper cuff's bladder size to be used is provided in Section 7.3 above.

■ Questions 4 to 6 - Pulse Obliteration Pressure

Record readings as described in "Methods" above.

■ Question 7 -Heart Rate

Record readings as described in "Methods" above.

■ Questions 8 to 14 - Blood Pressure

Record both Conventional and Random-Zero Sphygmomanometer readings as described in "Methods" above.

■ Question 15 -Which blood pressure measurement was taken first?

It is necessary that the order of the types of blood pressure measurements, standard seated or random-zero, be alternated. When direct on-line data entry occurs, the program determines the order of the blood pressure methods for the technician.

The order of the readings is determined by the participant's ID number. If the number is even, the standard reading is performed first. If the number is odd, the random-zero is first. If manual reporting is done, record which reading was performed first.

- Code "1 - Standard Seated Blood Pressure" if the conventional method was taken first.
- Code "2 - Random-Zero Blood Pressure" if this method was taken first.

- At the end of the form, Interviewer (technician) ID Number and date of the reading are to be recorded.

4 **References**

- 1) 1988 Joint National Committee, The 1988 Report of the Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure. Arch Intern Med, 148, 1988, pp.1023-1037.
- 2) Working Group on Hypertension in the Elderly, Statement on Hypertension in the Elderly. JAMA, 1986, 256, No. 1, pp. 70-74.
- 3) Labarthe DR, Palmer M. Measurement of Blood Pressure: A Manual for Training and Certification. Adapted for the Systolic Hypertension in the Elderly Program (SHEP). June 5, 1985.
- 4) Borhani N, LaBaw F, Dunkle S. Blood pressure measurement in an ambulatory setting. In: Ambulatory Blood Pressure Monitoring. New York: Springer-Verlag, 1984: 75-81.
- 5) Frohlich EC, Grim C, Labarthe DR, et al. Recommendations for human blood pressure determination by sphygmomanometers. Hypertension 1988; 11: pp. 209A-222A.
- 6) Atherosclerosis Risk in Communities Study (ARIC) Protocol, Manual 2: Cohort Component Procedures, Version 2.0 1/88. ARIC Coordinating Center, Suite 203 NCNC Plaza, 137 E. Franklin St, Chapel Hill, NC 27514.