CHRONIC KIDNEY DISEASE IN CHILDREN COHORT STUDY

SECTION 16: BLOOD PRESSURE MEASUREMENT

16.1 OVERVIEW OF BLOOD PRESSURE MEASUREMENT

This section describes the procedures that are to be performed to obtain correct measurement of blood pressure. Correct measurement of blood pressure is of the utmost importance to the success of this study since hypertension has been shown to be linked to the progression of CKD in children.

In the CKiD Study, blood pressure should be measured at every visit in a resting state using the Mabis Medic-Kit aneroid sphygmomanometer. Manual blood pressure measurement was chosen for CKiD because oscillometric devices may not be comparable between institutions and pediatric blood pressure normative values are based upon manual blood pressure measurements.

It is essential that the procedures described for measuring blood pressure be followed exactly. Precision is essential for valid blood pressure measurements since a specific aim of CKiD is to prospectively examine the influence of blood pressure and other cardiovascular risk factors on the progression of CKD in children.

16.2 BLOOD PRESSURE MEASUREMENT STEP BY STEP (Outline)

A. Equipment and Supplies:

_____ (1) Mabis Medic-Kit Aneroid Sphygmomanometer
_____ (2) Mabis Medic-Kit Cuffs - full set of 5 sizes
_____ (3) Stethoscope with a bell (pediatric head preferred)
_____ (4) Table at heart level to support arm
_____ (5) Accusplit (model 80226) Stopwatch (provided in CKiD starter package)
_____ (6) Measuring tape
_____ (7) Black ball point pen
_____ (8) Physical Exam Form (PE)

B. Arm Measurements

The following steps are properly carried out:

_____ (1) Participant standing
_____ (2) Arm bare from elbow to shoulder
_____ (3) Arm at 90 degree angle
_____ (4) Arm length measured from the acromion (or bony extremity of the shoulder girdle) to the olecranon (or tip of the elbow)
_____ (5) Midpoint of arm marked at dorsal aspect
_____ (6) Arm relaxed at side
_____ (7) Measure arm circumference with tape horizontal
_____ (8) No indentation of skin

_____ (9) Mark at midpoint of arm

_____ (10) Value checked with on the PE form to ascertain proper cuff size

_____ (11) Proper cuff size checked on the PE form

C. Preparation for BP Readings

_____ (1) Brachial artery palpated

_____ (2) Midpoint of bladder within the cuff located

_____ (3) Cuff applied with midpoint of bladder over brachial artery

_____ (4) Arm positioned with midpoint of cuff width at "heart" level; lower edge 2 to 3 cm (1 inch) above crease

_____ (5) Wait 5 minutes

_____ (6) Mabis Medic-Kit Aneroid sphygmomanometer connected to cuff

_____ (7) Sphygmomanometer scale is at eye level

_____ (8) radial pulse located

_____ (9) Cuff is inflated quickly to 60 mm Hg

_____ (10) Cuff is further inflated slowly by increments of 10 mm Hg (if pulse present at 60 mm Hg) until the pulse is no longer felt.

_____ (11) Cuff is quickly and completely deflated

_____ (12) Observed Pulse Obliteration value is correctly recorded on the PE form

_____ (13) The Correct Pulse Obliteration Pressure + 30 are added to get the Peak Inflation Level

D. Measurement of Blood Pressure

_____ (1) Brachial artery palpated

_____ (2) Stethoscope in ears

_____ (3) Bell over artery, without cuff or tubing contact

_____ (4) Cuff inflated quickly and smoothly to the Peak Inflation Level

_____ (5) Deflation at 2 mm Hg/second to 10 mm Hg below K5

_____ (6) Cuff quickly and completely deflated

_____ (7) Cuff disconnected

_____ (8) Recording of SBP and DBP values on the PE form

E. Between Readings

_____ (1) Cuff removed or tubing disconnected if uncomfortable

_____ (2) Arm raised passively overhead for 15 seconds. (Make sure the patient is not supporting the arm at all)

_____ (3) Arm lowered and cuff replaced with attention to brachial artery and midpoint of bladder; lower edge 2 to 3 cm (1 inch) above crease of the elbow. Note: There is a total of 30 seconds between readings.

_____ (4) Cuff reconnected

F. Second Seated Blood Pressure Reading

_____ (1) Conforms with procedures as in E above

G. Third Seated Blood Pressure Reading

_____ (1) Conforms with procedures as in E above

H. Completion

_____ (1) Complete PE Form

_____ (2) Closure of Mabis Medic-Kit Aneroid manometer case for storage

16.2 BLOOD PRESSURE MEASUREMENT STEP BY STEP (Detailed)

16.2.1 Overview

In this section, the step-by-step procedures for blood pressure measurement in the CKiD study are presented. It should be emphasized that the steps outlined here can satisfactorily be followed for the vast majority of child subjects participating in ambulatory follow-up. Exceptional situations do arise, with sometime serious obstacles to successful blood pressure measurement. The training program for a particular setting must include guidelines for handling such exceptions. Only a few will be noted. It will be the responsibility of the Clinical Coordinating Centers (to be named) and in the Data Coordinating Center (Jeanne Charleston) to encourage observers to note exceptional circumstances and to seek consultation with the DCC (Jeanne Charleston) when they arise so that participants will be appropriately evaluated. Mabis Medic-Kit sphygmomanometers should be used for blood pressure measurement for all CKiD clinic visits and for the determination of peak inflation levels. This section of the Manual of Procedures will concentrate on this device.

It should be noted also that the procedures listed here are illustrated in the third lecture presentation, "Blood Pressure Recording Procedures" (Section 27.2.3.3).

16.2.2 Preparation for Blood Pressure Measurement

Some of the many extraneous factors influencing blood pressure are controlled by standardizing the measurement technique and the environment in which the measurement is made. Uncontrolled factors (time of day, identity of the observer) are recorded, so that they can be taken into account during analysis.

Participants and/or parents should be instructed that the child is to abstain from caffeine, smoking, and exercise at least one-half hour prior to and until completion of the blood pressure measurement as appropriate. Current drug intake, including medications affecting blood pressure and non-prescription drugs, should be recorded on the day of the examination on the Medication and Supplement Inventory Form.

Try to keep the environment where blood pressure measurements are performed as pleasant as possible. Children and their parents should be given a full explanation and instructions about the preparation for the blood pressure examination and an opportunity for brief questions. The setting in which blood pressure measurements are made should take place in a separate, quiet room where no other activity is taking place, and where temperature fluctuations are minimal. Equipment (including PE form, sphygmomanometer, etc.) should be checked and waiting for the participant.

Allow five minutes of rest in this quiet room after arm measurement but before pulse is measured which occurs prior to taking the blood pressure. Explain to the child that the five-minute rest period will provide for more valid blood pressure measurements. Preferably, at this time, the observer should leave the room. The child should be seated with back supported with legs uncrossed and feet comfortably flat on the floor, not dangling. The patient should also be instructed to refrain from playing with video games, using a cell phone, or other activities that may affect blood pressure.

Blood pressure should not be taken with the child sitting on an examining table. The BP measurement is best taken by having the child seated in a chair next to a work table, having their right arm supported by the table, so that the BP cuff is at the level of the heart. If a measurement cannot be made on the right arm (due to casting, or fistula placement, etc.) then the BP should be taken on the left arm.

16.2.3 Blood Pressure Measurement Procedures

All blood pressure measurements taken by CKiD personnel should be obtained using the Mabis Medic-Kit Aneroid sphygmomanometer.

The sitting arm blood pressure is measured three times at each clinic visit. It takes approximately 15 minutes to obtain three blood pressure measurements including the initial five-minute rest.

Blood pressure equipment should be checked prior to seeing the participants. Once a participant is given instructions and explanations blood pressure measurement begins. The following steps must be followed precisely.

All blood pressure measurements conducted by CKiD Study Personnel on CKiD patients must be recorded on the PE forms, regardless of the clinical condition of the patient at the time of the measurement. If more than one blood pressure measurement is obtained on the same patient on the same day, then:

1. The Physical Exam Form (PE Form) must be completed for each blood pressure measurement that is taken.

2. The Physical Exam Form must be mailed with the other forms to the Clinical Coordinating Centers for data entry.

3. The complete CKiD protocol for blood pressure measurements must be followed for each measurement

Blood pressure measurements conducted by CKiD personnel on CKiD participants should be conducted at the CKiD clinical sites.

16.2.4 Stethoscope

A standard Littman stethoscope (or other comparable stethoscope) with a bell is used. A stethoscope with a pediatric head is recommended as the bell is small enough to be used on the arms of infants and small children. Korotkoff sounds are best heard with the bell because of their low pitch. Stethoscope tubing should be about 12 to 15 inches from the bell piece to "Y" branching. This length provides optimal acoustical properties and allows the observer to read the sphygmomanometer at eye level and in a comfortable position. Earpieces should fit comfortably and snugly in the ears. Four points should be observed in using the stethoscope.

1. The earpieces should be directed forward into the external ear canal.
2. The earpieces should be tight enough to exclude outside sound but not so tight that they cause discomfort.
3. The valve between the bell and the diaphragm should be turned in the direction of the bell.
4. The bell of the stethoscope should be placed lightly on the skin overlying the brachial artery - immediately below, but not touching, the cuff. The brachial artery is usually found above the crease of the arm, slightly towards the body. Light pressure accentuates low-pitched sound and avoids compression murmurs. Pressing too heavily with the stethoscope over the brachial artery causes turbulent flow in the artery and a murmur can be heard which may prolong the apparent duration of fourth-phase Korotkoff sounds.

16.2.5 Arm Measurement and Cuff Sizes

The proper cuff size must be used to avoid under- or over-estimating the correct blood pressure. Recently issued pediatric guidelines on cuff size have simplified the cuff selection process by stating that proper blood pressure measurement will be achieved so long as the length of the cuff bladder is equal to 80-100% of the arm circumference. To determine the proper cuff size, the observer must measure the arm circumference at the midpoint of the arm at each visit. This procedure follows:

1. Expose (bare) the right arm from the shoulder.
2. With the participant standing, holding the forearm horizontal, measure the arm length from the acromion (or bony extremity of the shoulder girdle) to the olecranon (or tip of the elbow) with a plastic coated metric tape.
3. Mark the midpoint on the dorsal surface with a pen.
4. Instruct the participant to relax the arm along the side of the body.
5. Measure the arm circumference by drawing the tape snugly around the arm at the level of the midpoint marking. Care must be taken to keep the tape horizontal and the tape should not indent the skin.
6. Record on the PE form the arm circumference measurements and corresponding cuff sizes (shown below).
7. Check the indicated cuff size on the PE form.

Since arm circumference may change over the course of the study due to growth, this measurement procedure should be repeated at each visit where blood pressure is to be measured. **Do not use the cuff itself as a measurement device because the ranges marked on the cuff may not correspond with the table.**

Determination of Cuff Size Based on Arm Circumference

Arm Circumference	**Cuff Size (Mabis Medic-Kit)**
9 to 14.0 cm	Infant
>14.0 to 21.0 cm	Child
>21.0 to 29.0 cm	Adult, Regular
>29.0 to 40.0 cm	Large Adult
>40.0 to 52.0 cm	Thigh

16.2.6 Application of the Blood Pressure Cuff

The appropriate cuff (as determined in the arm measurement procedure) is placed 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. The lower edge of the cuff, with its tubing connections, should be placed about 1 inch above the natural crease across the inner aspect of the elbow. The cuff is wrapped snugly about the arm, with the palm of the participant's hand turned upward. The wrapped cuff should be secured firmly by means of the Velcro on the cuff.

16.2.7 Determining the Peak Inflation Level

For each participant it is necessary to determine the pressure level to which the cuff is to be inflated for accurate measurement of the systolic pressure. This is because the pressure at the start of the reading should always exceed the systolic blood pressure, otherwise the first of the Korotkoff sounds will be missed (see Lecture #1). This starting pressure is called the Peak Inflation Pressure and is determined as follows.

- First, the cuff tubing should be attached to the Mabis Medic-Kit Aneroid sphygmomanometer.
- While palpating the radial pulse (at the wrist), observe sphygmomanometer and inflate the cuff rapidly to 60 mmHg and then slowly inflate in increments of 10 mmHg until the pulse is no longer felt.
- If the pulse is still felt, the cuff pressure should be increased until the pulse disappears. Either the first or the second of these procedures will identify the Observed Pulse Obliteration Pressure. Record on the PE Form.
- When this has been detected, the cuff is quickly and completely deflated.
- The Observed Pulse Obliteration Pressure is then added to 30 mmHg.
- This summed value is the Peak Inflation Level. The cuff is to be inflated to this level for all readings at this examination.

NOTE: All readings on the sphygmomanometer are made to the nearest even digit. Any reading that appears to fall exactly between markings on the column should be read to the next marking immediately above, i.e., 2, 4, 6, 8, or 0.

16.2.9 Blood Pressure Readings

Next, the observer should proceed to carry out the first blood pressure reading. Detailed instructions are given below for measuring blood pressure with a Mabis Medic-Kit Aneroid sphygmomanometer.

16.2.10 Measuring Blood Pressure with a Mabis Medic-Kit Aneroid Device

The steps for readings with the Mabis Medic-Kit Aneroid device are described below.

(1) Wait at least 30 seconds after complete deflation of the cuff following any preceding inflation. Palpate the brachial artery at the elbow, slightly toward the elbow. Mark with a pen the location of the palpated artery.
(2) Connect the cuff to the Mabis Medic-Kit Aneroid device.
(3) Place the ear pieces of the stethoscope into the ears, with the tips turned forward.
(4) Apply the bell of the stethoscope over the marked brachial artery location, just below but not touching the cuff or tubing.
(5) Using the previously determined peak inflation level, rapidly inflate to this level. The eyes of the observer should be focused on the dial of the aneroid sphygmomanometer. The observer should rapidly inflate the cuff.
(6) By slightly adjusting the valve, deflate and maintain a constant rate of deflation at approximately 2 mm Hg 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 of two consecutive beats is heard), until 10 mm Hg below the level of the diastolic reading (that is, 10 mm Hg below the level where the last of two consecutive beats is heard).
(7) Open the valve to deflate fully and disconnect the tubing. Remove the stethoscope earpieces from the ears.

(8) Record the systolic and diastolic reading on the PE form.

(9) Repeat steps 3 through 9 two more times, waiting at least 30 seconds after complete deflation of the cuff following any preceding inflation. These are the Second and Third Mabis Medic-Kit Aneroid Blood Pressure Values. Note: After the first and second readings, the patient's arm should be raised for 15 seconds. The arm is then lowered. Wait an additional 15 seconds. There is a total of 30 seconds between readings.

(10) Ways to accentuate Korotkoff sounds: 1) While using the standard technique, rapidly inflate the cuff while the participant's arm is elevated, then, bring the participant's arm back to heart level and begin taking the reading. Or, 2) After the cuff is rapidly inflated to the Peak Inflation Level, have the participant rapidly open and close his or her fist six to eight times. Then, instruct the participant to relax their arm and begin taking the reading.

16.2.11 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 aneroid dial. The systolic value can be identified as the pressure level where the first of 2 or more consecutive beats are heard in appropriate rhythm. The diastolic value can be identified as the pressure level where the last of two consecutive beats heard. The aneroid dial 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.

PLEASE 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.

In some patients, the disappearance of sound, i.e. the fifth Korotokoff sound, never occurs and beats can be heard during the entire deflation period. In these circumstances, the fourth Korotokoff sounf should be used to determine the diastolic blood pressure. The fourth Korotokoff sound at the point during deflation where the quality of the sound changes dramatically (e.g. the quality of the beat becomes muffled).

16.2.12 Forgotten Blood Pressure Readings

If for any reason the observer is unable or has forgotten to complete any portion of the PE exam, and the participant is gone, leave the items blank on the paper form. If a blood pressure value is missed or forgotten, completely deflate the cuff and start over with a replacement reading after the proper interval. Do not re-inflate the blood pressure cuff during a reading. However, under no other circumstances may a replacement reading be obtained. Once the study measurement procedure has begun, record all observations. Do not redo a reading that looks unusual to you.

16.2.13 Reporting the Blood Pressure Results to the Participant

The patient may wish to know his or her results before the form is sent to the Clinical Coordinating Center for data entry. If so, average the first, second, and third Mabis Medic-Kit Aneroid readings and give the results to the participant. State clearly the systolic and diastolic pressures and offer to write down these values for the participant.

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Some text adapted from the ARIC Protocol 11:
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