Measurement of Blood Pressure in Children: Recommendations and Perceptions on Cuff Selection

Majda Arafat, MD*, and Tej K. Mattoo, MD, DCH, FRCP (UK)†

ABSTRACT. Objectives. To review some of the recent recommendations on blood pressure (BP) cuff selection, including those by the Task Force and its update, and to survey the perceptions on cuff selection among practitioners.

Methods. The study was conducted in two parts. In the first, we selected three brands of commonly used infant, child/pediatric, small adult, adult, and large adult BP cuffs. From the median width of each, we derived the required upper arm length (UAL) for the cuff to cover three quarters or two thirds of the UAL, and with the help of a published normal UAL at various ages, we matched the derived UAL with the corresponding age at the 50th percentile. Similarly, we derived the midupper arm circumference (UAC) so that the available cuffs would cover 40% of the UAC, and by using the published normal UAC at various ages, we matched the derived UAC with the corresponding age at the 50th percentile.

The second part of the study involved a survey by multiple choice questionnaire mailed to 400 hospital- and office-based pediatricians, residents, and nurses at the Children’s Hospital of Michigan. Included in the survey were questions about the age at which practitioners would choose the cuffs described above; the minimum age they would consider using an adult cuff in a pediatric patient with an average height and weight; selecting a cuff using UAL as a criterion; selecting a large versus a small cuff when the appropriate cuff size is not available; and the Task Force definition of hypertension. Results. Using three quarters of the UAL as a criterion, it seems that a large adult cuff should be appropriate for an average-size 6-year-old child and that using two thirds of UAL as a criterion, the cuff should be appropriate for an average-size 7- to 8-year-old child. Similarly, by using 40% of the mid-UAC as a criterion, an adult cuff would be of no use in an average pediatric patient at any age. Our survey revealed that 57% of practitioners would consider using a neonatal cuff for patients up to 1 month of age, 65% would use an infant cuff for those 1 year of age, 49% would use a child/pediatric cuff for those 5 years of age, and 84% would use a small adult cuff for those 10 years of age and older. Most (83%) of the practitioners would consider using an adult cuff in children 11 years of age and older. Practitioners are likely to use a smaller cuff than is appropriate by two thirds or three quarters of UAL criteria, and a larger cuff than is appropriate, particularly in older children, by 40% of UAC criteria. Using UAL as a criterion, a majority (59%) of practitioners use cuffs that cover two thirds of the distance between the axilla and the cubital fossa. Ninety-two percent of practitioners believe that a smaller cuff causes a moderate to significant increase in the BP reading, and 55% believe that a larger cuff causes a similar decrease in the BP reading. A significant number of practitioners (44%) did not know the Task Force definition of hypertension, including 42% of attendings, 44% of residents, and 50% of nurses.

Conclusions. The Task Force and the Working Group recommendations on BP cuff selection need to be reviewed. A new multicenter study, using uniform criteria for cuff selection, may be necessary to establish the accuracy of the published nomogram on normal BP in children. More awareness is required on part of practitioners of the current recommendations on BP measurement and the definition of hypertension. Finally, the labeling of BP cuffs as infant, pediatric, small adult, adult, and large adult is misleading, and such designations should be eliminated. Cuff sizes should be standardized, indicate bladder size, and be uniformly color-coded for convenience. Pediatrics 1999;104(3).

ABBREVIATIONS. BP, blood pressure; UAL, upper arm length; UAC, upper arm circumference.

Measurement of blood pressure (BP) generally is considered to be an integral part of a clinical examination. A number of factors affect the accuracy of measurement, including the equipment itself, observer bias, position of the arm, and the mental status of the patient. Determination of the appropriate BP cuff size is crucial because in general, a smaller cuff contributes to a higher BP reading, whereas a larger cuff underestimates the BP reading. This is of particular importance in children because of their varying arm sizes at various ages. For this reason, cuffs used in children come in various sizes, often labeled neonatal, infant, child and/or pediatric, small adult, adult, and large adult or thigh cuff. The most widely known recommendations on cuff selection and the nomogram for BP in children are from the Task Force on Blood Pressure Control in Children and its update by the National High Blood Pressure Education Program Working Group on Hypertension Control in Children and Adolescents. According to the 1987 report, the BP cuff bladder should be wide enough to cover three quarters of the upper arm length (UAL) from the
acromion to the olecranon. In its update in 1996, the working group recommended that the width of the cuff bladder should equal 40% of the midupper arm circumference (UAC). These recommendations, however, were based on pooled data from various studies that used different criteria for cuff selection. The purpose of this study is to review some of the criteria for cuff selection and to survey the perceptions of BP measurement among practitioners responsible for the care of children.

PATIENTS AND METHODS

The study was conducted in two parts. In the first, we selected three commonly used brands of BP cuffs (Hewlett Packard, Palo Alto, CA; Cas Tuff-Cuff, Life Assist, Rancho Cordova, CA; and Dura-Cuf, Critikon Co, L.L.L., Tampa, FL), and grouped them according to the cuff’s size designation as infant, child/pediatric, small adult, adult, and large adult. The median cuff bladder width of the three brands for various ages was used as a standard for comparison (Table 1). For each of the medians, we derived the required UAL (Table 2) so that the cuff would cover the three quarters’ UAL as recommended in the Task Force report, and the two thirds’ UAL as used in some studies cited by the Task Force. Subsequently, with the help of published normal UAC at various ages, we matched the derived UAL with the corresponding age at the 50th percentile. Similarly, we derived the UAC required for various cuffs so that the width of the cuff would equal 40% of the UAC, as recommended in the Task Force update. By using the published normal UAC at various ages, we matched the derived UAC with the corresponding age at the 50th percentile (Table 3).

Part two of the study involved a survey by multiple choice questionnaire mailed to 400 hospital- and office-based practitioners, residents, and nurses at the Children’s Hospital of Michigan. Included in the survey were questions about the age at which the practitioners would choose the cuffs described above (Table 4); the minimum age they would consider using an adult cuff in a pediatric patient; the median 6 8.25 11 14 17

<table>
<thead>
<tr>
<th>Manufacturer/Brand Name</th>
<th>Infant</th>
<th>Child/Pediatric</th>
<th>Small Adult</th>
<th>Adult</th>
<th>Large Adult</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hewlett Packard</td>
<td>6 and 8</td>
<td>8.25/10</td>
<td>10.5</td>
<td>14</td>
<td>17</td>
</tr>
<tr>
<td>Cas Tuff-Cuff</td>
<td>6</td>
<td>7.9</td>
<td>12</td>
<td>14</td>
<td>16</td>
</tr>
<tr>
<td>Dura-Cuf</td>
<td>5.25</td>
<td>8/-</td>
<td>11</td>
<td>14</td>
<td>17</td>
</tr>
</tbody>
</table>

DISCUSSION

The measurement and interpretation of BP in children are complicated by a need for different BP cuffs at various ages, as well as by age-, sex-, and height-dependent variations in normal BP. Diagnosis of hypertension is crucial because a significant percentage of such children, preadolescents in particular, are believed to have an underlying pathology that may require an extensive work-up. An inaccurate diagnosis may have serious consequences or may lead to unnecessary follow-up, referrals, investigations, and treatment, as well as to anxiety for the patient and family.
TABLE 2. Approximate Ages at Which the Available Cuffs Would Cover Three Quarters and Two Thirds of the UAL.

<table>
<thead>
<tr>
<th>Available BP Cuffs as Mentioned in Table 1 (Median Width in Centimeters)</th>
<th>Three Quarters of the UAL</th>
<th>Two Thirds of the UAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>UAL (cm) Needed for the BP Cuff to Cover</td>
<td>The Corresponding Age for the Mean UAL (19–21)</td>
<td>UAL (cm) Needed for the BP Cuff to Cover</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infant (6)</td>
<td>8</td>
<td>1 y*</td>
</tr>
<tr>
<td>Child/pediatric (8.25)</td>
<td>11</td>
<td>1 y*</td>
</tr>
<tr>
<td>Small adult (11)</td>
<td>14.6</td>
<td>3 y*</td>
</tr>
<tr>
<td>Adult (14)</td>
<td>18.6</td>
<td>5–6 y*</td>
</tr>
<tr>
<td>Large adult (17)</td>
<td>22.6</td>
<td>6 y‡</td>
</tr>
</tbody>
</table>

* Derived from the diaphyseal length of humerus on x-ray at various ages. 20
† 5th Percentile for UAL at 6 years in boys and girls is 21.6 and 21.2 cm, respectively.
‡ 25th Percentile for a 6 year old child. 21

TABLE 3. Approximate Ages at Which the Available Cuffs Would Cover 40% of the UAC.

<table>
<thead>
<tr>
<th>Available BP Cuffs as Mentioned in Table 1 (Median Width in Centimeters)</th>
<th>UAC (cm) Needed for the BP Cuff to Cover 40%</th>
<th>The Corresponding Age (y) for the Mean UAC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>22</td>
</tr>
<tr>
<td>Infant (6)</td>
<td>15</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Child/pediatric (8.25)</td>
<td>20.6</td>
<td>10</td>
</tr>
<tr>
<td>Small adult (11)</td>
<td>27.5</td>
<td>10</td>
</tr>
<tr>
<td>Adult (14)</td>
<td>35</td>
<td>25</td>
</tr>
<tr>
<td>Large adult (17)</td>
<td>42.5</td>
<td>30</td>
</tr>
</tbody>
</table>

* Maximum UAC for an average-size adult male and female are 32.6 cm and 30.3 cm, respectively.
** Above the 95th percentile for any age group.

Selection of the correct BP cuff has been the subject of an intense, apparently unresolved, debate. The most publicized recommendations were published by the Task Force and its update by the Working Group. 6 In 1987, it recommended that the BP cuff should cover three quarters of the UAL, from acromion to olecranon. 5 According to the 1996 update, the cuff should be wide enough to cover 40% of the UAC. The report notes that such a cuff “will cover 80% to 100% of the circumference of the arm.” It does not give any explanation for the change from the previous recommendation, but it is most probably based on the evidence that the correct ratio of bladder width to arm circumference is 0.4, and the bladder width should be 40% to 50% of UAC. Of note is that many well known textbooks endorse different criteria for cuff selection. According to a chapter on childhood hypertension in the textbook Hypertension, the cuff should be wide enough to cover at least 75% to 80% of the arm between the antecubital fossa and the axilla. The Nelson Textbook of Pediatrics and Rudolph’s Pediatrics recommend that the cuff cover approximately two thirds of the UAL. Neither define the length of the upper arm. According to another well known textbook, Primary Pediatric Care, the optimal cuff size covers two thirds of the distance between the antecubital fossa and the shoulder. A different chapter in the same book recommends that the cuff should cover approximately 75% of the upper arm. In consideration of such diverse and at times ambiguous recommendations, it is not surprising that there is no uniform criteria among pediatricians for cuff selection.

A review of some of the common recommendations on cuff selection reveals that by using three quarters of the UAL as a criterion, an infant cuff should be appropriate for a newborn and a large adult cuff should be appropriate for a 6-year-old child who is at the 25th percentile for UAL (Table 2). Using two thirds of the UAL as a criteria, an adult cuff should be appropriate for children younger than age 6 and a large adult cuff should be appropriate for average-size 7– to 8-year-old children (Table 2). Using 40% of the UAC as a criterion (Table 3), an infant cuff should be appropriate for an average-size infant, a child/pediatric cuff should be appropriate for an average-size 10-year-old child, and a small adult cuff should be appropriate for an average-size 16-year-old male and an average-size 25-year-old female. In fact, the ideal arm circumference recommended by the Task Force because the data are derived from studies that used different criteria, including those noted above, for cuff selection.

Our survey revealed that the perception of cuff selection by health care providers does not conform to any of the criteria discussed in this article. They are likely to use a much smaller cuff than is appropriate according to the two-thirds’ or three-quarters’ UAL criteria. An overwhelming majority of practitioners (83%) would consider using an adult cuff for patients age 11 and older, although according to the two-thirds’ or three-quarters’ UAL criteria, it should be appropriate for a child approximately 6 years old. On the contrary, the practitioners are likely to use a larger cuff, particularly in older children, than is appropriate, according to the 40% UAC criteria. Approximately half (49%) of the practitioners would consider using a child/pediatric cuff for 5-year-olds, although according to the 40% UAC criteria, it should be appropriate for an average-size 10-year-old.
old child. The survey also revealed that a majority (59%) of practitioners use two thirds of the inner upper arm as a criterion for the cuff selection (Table 5). This is compatible with an unpublished common belief that the upper arm is the distance measured between the axilla and the cubital fossa rather than from the acromion to the olecranon process, a belief exacerbated by a lack of clear definition in the textbooks.23,25 In response to the question of choosing a large versus a small cuff when the appropriate cuff is not available (Table 6), 92% of practitioners believe that a smaller cuff is likely to cause a moderate to significant error in BP measurement. In comparison, only 55% believe that a similar error could occur with a larger size cuff. The remaining 45% believe that such a cuff has no effect to a slight effect on the measured BP. This perception is compatible with findings from some studies that revealed that the margin of error with a smaller cuff is higher than that with a larger cuff.2–4 According to Karvonen and associates,31 a larger-than-appropriate cuff can give systolic values 3.0 ± 1.16 mm Hg lower, whereas a smaller cuff can give systolic values 5.5 ± 1.91 mm Hg higher. Finally, a significant number (44%) of our practitioners did not know the correct definition of hypertension, which, according to the Task Force is “average systolic or diastolic BP greater than or equal to the 95th percentile for age and sex measured on at least three separate occasions.” No difference was seen among attendings, residents, and nurses in their knowledge of the correct definition.

CONCLUSION
In summary, the Task Force and the Working Group recommendations on BP cuff selection need to be reviewed. A new multicenter study, using uniform criteria for cuff selection, may be necessary to establish the accuracy of the published nomogram on normal BP in children. More awareness is required on part of practitioners about the current recommendations on BP measurement and the definition of hypertension. Labeling of BP cuffs as infant, pediatric, small adult, adult, and large adult is misleading and such designations should be eliminated. Cuff sizes need to be standardized, indicate bladder size, and be uniformly color-coded for convenience.

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