

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

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**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). URL: <http://www.pediatrics.org/cgi/content/full/104/3/e30>; *blood pressure, measurement, cuff size, children, survey.*

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.<sup>1</sup> 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.<sup>2-4</sup> 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.<sup>5,6</sup> 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

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acromion to the olecranon.<sup>5</sup> 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).<sup>6</sup> These recommendations, however, were based on pooled data from various studies that used different criteria for cuff selection.<sup>7-18</sup> 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, LLL, 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,<sup>5</sup> and the two thirds' UAL as used in some studies cited by the Task Force.<sup>9,12,14,16</sup> Subsequently, with the help of published normal UAL at various ages,<sup>19-21</sup> 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.<sup>6</sup> By using the published normal UAC at various ages,<sup>22</sup> 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 pediatricians, 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 with an average height and weight; selecting a cuff by using UAL as a criterion (Table 5); selecting a large versus a small cuff when an appropriate cuff size is not available (Table 6), and the Task Force definition of hypertension.

## RESULTS

As presented in Table 2, using three quarters of the UAL as a criterion for BP cuff selection, an infant cuff should be appropriate for a newborn with a mean UAL of 8 cm. A large adult cuff with a median width of 17 cm would be appropriate for an UAL of 22.6 cm, which is the 25th percentile for UAL in a 6-year-old child. Using two thirds of the UAL as a criterion (Table 2), an adult cuff with a median width of 14 cm should be appropriate for an UAL of 21 cm, which is the 5th percentile for a 6-year-old child. Similarly, a large adult cuff with a median width of 17 cm should be appropriate for a 7- to 8-year-old child with an average UAL of 25.5 cm. Using 40% of the UAC as a criterion (Table 3), a 6-cm infant cuff should be appropriate for an average-size infant, and a child/

pediatric cuff should be appropriate for a 10-year-old with an average UAC of 20.6 cm. A small adult cuff should be appropriate for an average-size 16-year-old male and a 25-year-old female with a mean UAC of 27.5 cm. A 14-cm adult cuff would be appropriate for an UAC of 35 cm, which is more than the average UAC of any age child or adult.

In the second part of the study, 210 (52.5%) practitioners responded to the survey. Included were 87 attending pediatricians, 68 residents in training, and 55 nurses. As presented in Table 4, 57% of practitioners believe that a neonatal cuff is appropriate for infants up to 1 month of age, 65% would use an infant cuff for a 1-year-old child, 49% would use a child/pediatric cuff for a 5-year-old child, and 84% would use a small adult cuff for children age 10 years and older. Of the respondents, 82 attendings, 68 residents, and 53 nurses answered the question on the minimum age they would consider using an adult cuff in an average-size pediatric patient; 35 (43%), 31 (46%), and 27 (51%), respectively, indicated that they would do so at a minimum age of 11 years. Of the total 203 respondents, 4 (2%) indicated said that they would consider using an adult cuff for a child at least 5 years of age; 31 (15%) indicated 8 years; 93 (46%) indicated 11 years; 66 (33%) indicated 14 years, and 9 (4%) indicated 17 years. As presented in Table 5, 59% of the practitioners use two thirds of the upper arm between the axilla and the antecubital fossa as a criterion for cuff selection. Ninety-two percent believe that a smaller cuff causes a moderate to significant increase in the measured BP, and 55% believe that a larger cuff causes a similar decrease in the measured BP (Table 6). A total of 198 practitioners answered the question on the Task Force definition of hypertension; 110 (56%) responded correctly, including 49 of 84 attendings (58%), 38 of 68 residents (56%), and 23 of 46 nurses (50%).

## 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.<sup>23</sup> 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 1.** Commercially Available BP Cuffs

Manufacturer/ Brand Name	Width of the Cuff in Centimeters				
	Infant	Child/Pediatric	Small Adult	Adult	Large Adult
Hewlett Packard	6 and 8	8.25/10	10.5	14	17
Cas Tuff-Cuff	6	7/9	12	14	16
Dura-Cuf	5.25	8/-	11	14	17
Median	6	8.25	11	14	17

**TABLE 2.** Approximate Ages at Which the Available Cuffs Would Cover Three Quarters and Two Thirds of the UAL

Available BP Cuffs as Mentioned in Table 1 (Median Width in Centimeters)	Three Quarters of the UAL		Two Thirds of the UAL	
	UAL (cm) Needed for the BP Cuff to Cover Three Quarters UAL	The Corresponding Age for the Mean UAL (19–21)	UAL (cm) Needed for the BP Cuff to Cover Two Thirds UAL	The Corresponding Age for the Mean UAL <sup>20,21</sup>
Infant (6)	8	Birth	9	0–6 mo*
Child/pediatric (8.25)	11	1 y*	12.38	1–2 y*
Small adult (11)	14.6	3 y*	16.5	4–6 y*
Adult (14)	18.6	5–6 y*	21	6†
Large adult (17)	22.6	6 y‡	25.5	8

\* Derived from the diaphyseal length of humerus on x-ray at various ages.<sup>20</sup>

† 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.<sup>21</sup>

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

Available BP Cuffs as Mentioned in Table 1 (Median Width in Centimeters)	UAC (cm) Needed for the BP Cuff to Equal 40%	Corresponding Age (y) for Mean UAC <sup>22</sup>	
		Male	Female
Infant (6)	15	<1	<1
Child/pediatric (8.25)	20.6	10	10
Small adult (11)	27.5	16	25
Adult (14)	35	*	*
Large adult (17)	42.5	**	**

\* 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<sup>5</sup> and its update by the Working Group.<sup>6</sup> In 1987, it recommended that the BP cuff should cover three quarters of the UAL, from acromion to olecranon.<sup>5</sup> According to the 1996 update, the cuff should be wide enough to cover 40% of the UAC.<sup>6</sup> 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.<sup>24</sup> 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.<sup>25</sup> The *Nelson Textbook of Pediatrics* and *Rudolph’s Pediatrics* recommend that the cuff cover approximately two thirds of the UAL.<sup>26,27</sup> 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.<sup>28</sup> A different chapter in the same book recommends that the cuff should cover approximately 75% of the upper arm.<sup>29</sup> 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 *Report of a Special Task Force Appointed by the Steering Committee* by the American Heart Association is 30 cm for a 12-cm cuff, 37.5 for a 15-cm cuff, and 45 cm for an 18 cm-cuff.<sup>30</sup> Accordingly, a 14-cm regular-size adult cuff would be appropriate for an UAC of 35 cm, which is more than the average UAC for adult males and females (32.6 cm and 30.3 cm, respectively).<sup>22</sup> Such a cuff therefore would be of no use in any average-size pediatric or adult patient and, by the same criteria, only 10% of people at any age, pediatric or adult, should require a large adult cuff. These observations reveal inconsistencies and shortcomings in various methods of cuff selection, and there may be a need to review BP nomogram published 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-

**TABLE 4.** Age at Which Practitioners Would Consider Using Various Cuffs for BP Measurement in Children With Average Height and Weight

Respondents Who Participated in the Survey (n)	Neonatal Cuff			Infant Cuff			Child/Pediatric Cuff			Small Adult Cuff		
	1 Month	2 Months	3 Months	6 Months	1 Year	2 Years	3 Years	5 Years	8 Years	4 Years	7 Years	≥10 Years
	<i>n</i> (%)			<i>n</i> (%)			<i>n</i> (%)			<i>n</i> (%)		
Attendings (87)	40 (51)	16 (21)	22 (28) [78]	4 (5)	57 (73)	17 (22) [78]	2 (3)	27 (34)	51 (64) [80]	2 (3)	5 (7)	67 (91) [74]
Residents (68)	34 (62)	13 (24)	8 (15) [55]	7 (13)	36 (65)	12 (22) [55]	6 (11)	32 (60)	15 (28) [53]	1 (2)	11 (23)	36 (75) [48]
Nurses (55)	30 (59)	11 (22)	10 (20) [51]	20 (40)	26 (52)	4 (8) [50]	4 (8)	31 (62)	15 (30) [50]	0 (0)	8 (16)	41 (84) [49]
Total (210)	104 (57)	40 (22)	40 (22) [184]	31 (17)	119 (65)	33 (18) [183]	12 (7)	90 (49)	81 (44) [183]	3 (2)	24 (14)	144 (84) [171]

Number in brackets indicates number of respondents who answered each question.

**TABLE 5.** Appropriate Cuff Size, Wide Enough to Cover UAL

Respondents Who Answered the Question	Distance From Axilla to Antecubital Fossa			Distance From Acromion to Olecranon Process		
	1/2	2/3	3/4	1/2	2/3	3/4
Attendings (82)	9 (11%)	49 (60%)	8 (10%)	3 (4%)	13 (16%)	0 (0%)
Nurses (52)	3 (6%)	29 (56%)	14 (27%)	2 (4%)	3 (6%)	1 (2%)
Residents (67)	1 (1%)	40 (60%)	4 (6%)	4 (6%)	14 (21%)	4 (6%)
Total (201)	13 (6%)	118 (59%)	26 (13%)	9 (4%)	30 (15%)	5 (2%)

**TABLE 6.** Effect of a Large versus Small Cuff on BP Measurement When the Appropriate-Size Cuff Is Not Available

Respondents Who Answered the Question (n)	Measured BP Increase With Cuff One Size Smaller				The Measured BP Decrease With Cuff One Size Larger			
	Significant (%)	Moderate (%)	Slight (%)	None (%)	Significant (%)	Moderate (%)	Slight (%)	None (%)
Attendings (82)	23 (28)	51 (62)	8 (10)	0 (0)	10 (12)	27 (33)	28 (34)	17 (21)
Residents (67)	34 (51)	29 (43)	4 (6)	0 (0)	10 (15)	23 (34)	27 (40)	7 (10)
Nurses (53)	23 (43)	26 (49)	4 (8)	0 (0)	17 (32)	25 (47)	9 (17)	2 (4)
Total (202)	80 (40)	106 (52)	16 (8)	0 (0)	37 (18)	75 (37)	64 (32)	26 (13)

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.<sup>23,25</sup> 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.<sup>2-4</sup> According to Karvonen and associates,<sup>31</sup> a larger-than-appropriate cuff can give systolic values  $3.0 \pm 1.16$  mm Hg lower, whereas a smaller cuff can give systolic values  $5.5 \pm 1.91$  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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