International Journal of Contemporary Pediatrics
Naushad A et al. Int J Contemp Pediatr. 2023 Jul;10(7):1077-1082
http://www.ijpediatrics.com
pISSN 2349-3283 | eISSN 2349-3291

DOI: https://dx.doi.org/10.18203/2349-3291.ijcp20231846

Original Research Article

The average value of mean arterial pressure among children aged 3-10 years as per age, gender and height centiles: A cross sectional study

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Received: 03 May 2023
Revised: 06 June 2023
Accepted: 13 June 2023

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ABSTRACT

Background: Objective of the study was to find out the average MAP among children aged between 3-10 years based on age, gender and height centiles and to study the correlation of MAP with weight, height and BMI.
Methods: A total of 502 children were included in the study. First the demographic details of the children was collected. Then anthropometric parameters were measured. Systolic BP, Diastolic BP and MAP were recorded. SPSS version 20 was used for statistical analysis.
Results: MAP has got a positive correlation with weight, height and BMI.
Conclusions: The mean MAP of male children, 3-4 years 75±9 mmHg, 5-6 years 75±8 mmHg, 7-8 years 76±7 mmHg, 9-10 years, 79±11 mmHg. The mean MAP of female children, 3-4 years 77±7 mmHg, 5-6 years 77±8 mmHg, 7-8 years 78±9 mmHg, 9-10 years, 79±8 mmHg. MAP was found to be highly correlated with weight, height and BMI.

Keywords: Children, Mean arterial pressure, Anthropometric parameters

INTRODUCTION

Mean arterial pressure (MAP) is a critical hemodynamic factor. Main determinants of Mean arterial pressure (MAP) is cardiac output and systemic vascular resistance (SVR). It is the steady-state component of blood pressure. Lack of proper regulation of MAP can have severe pathophysiological consequences. Low MAP can cause inadequate blood flow to organs. An increase in MAP contributes to increased oxygen demand by the heart, ventricular remodeling, vascular injury, end organ damage, and stroke. The key controller of MAP is arterial baroreflex system.[1]

MAP is an important indicator to identify tissue perfusion.2 Diagnosis of hypertension and hypotension in paediatric critical care unit is mostly based on mean arterial pressure. Non-invasive MAP reading using the automatic oscillometric technique with an upper arm inflatable cuff is the most used method. This method is the easiest, relatively fast and cheapest one.

The most common indication for MAP monitoring is for continuous evaluation for hemodynamically unstable paediatric patients. Invasive MAP monitoring has been used in critically ill paediatric patients. MAP helps in the immediate diagnosis of cardiovascular insufficiency. MAP can be also measured by using various formulas using diastolic and systolic pressure.

It has been found that there are not many studies on the normal range of mean arterial pressure in a particular age

group. This study will be definitely useful in assessing normal mean arterial pressure of children between 3-10 years of age. The normal values obtained from this study can be used for assessing hemodynamic stability of sick children in critical Care units.

METHODS

This was a cross sectional study done in Primary schools and Anganwadi centres in Calicut district. Children aged 3-10 years were selected for the study. Study done for 1.5 years (October 2018 to May 2020) on 500 people.

Sample size was calculated using the formula,

$N = Z^2S^2 /2L$

Where N=Sample size, S=10 mmHg, approximate standard deviation of systolic blood pressure. L=3mmHg (allowable error limit of estimate) Z = 1.65 (Value of Z if standardized normal distribution at 90 per cent confidence limit. Putting these values in the formula we got N = 30.25, approximately 30 subjects in each year of age and sex. Accordingly total sample size obtained was 480 because the study was planned to conduct in either sex in the age range from 3 to 10 years that is 16 age sex subgroups in all. So we took a sample size of 500.

Inclusion criteria

All children aged 3-10 years irrespective of gender were included in the study

Exclusion criteria

Children without consent of parents and those who were crying at the time of study and children having any infection, pain and other significant illness (Cardiac, Renal disease) at the time of study were excluded.

Methodology

Schools were randomly selected after prior permission from the concerned authorities. Parents of the children were informed by the school and anganwadi authorities prior to the day of visit and consent of the parents were obtained. In anganwadis parents were also called on the same day. On the day of visit importance of the study was explained to the school management, staffs, teachers and parents. First demographic details and other significant history were collected from children in schools and parents in anganwadis. Then weight and height was measured. Measurements were made by a single person (who was trained prior for taking all measurements) and same equipment was used with appropriate sized cuff to obtain accurate measurements and to increase sensitivity of results. Height was measured by making the child to stand upright barefoot, on the ground with heels, buttocks and shoulder touching the wall and head in frankfurt plane by using a non-flexible measuring tape to nearest 1 cm. Weight was recorded using a weighing machine (Detek 009 digital LCD electronic weighing scale) to nearest 1kg. BMI was calculated using quetlet index. Then systolic BP, diastolic BP and mean arterial pressure were recorded using NIBP monitors (Philips BEMP 0206) (According to American Heart Association guidelines).

Measurement of blood pressure

Child was seated comfortably, with back supported, legs uncrossed and upper arm bared. Child's arm was supported at heart level. All clothing covering the cuff location was removed. Cuff bladder encircled 80% or more of the child's arm circumference. Cuff width was at least 40% of the arm circumference half way between the olecranon and acromion. Two readings were taken with one minute interval between them and average of the measurement recorded. Additional readings were taken if the difference between the first two is greater than 5 mmHg.

Statistical analysis

SPSS version 20 was used for statistical analysis. Qualitative (categorical) variables were represented by frequency and percentage analysis. Quantitative (continuous/score) variables were represented by mean and standard deviation. Mean arterial pressure was represented using percentiles. Analysis of variance (ANOVA) was performed to find the relationship between mean arterial pressure and age. Independent sample t-test was performed to find the relationship between mean arterial pressure and gender / gestational age. Pearson correlation coefficient was calculated to find the correlation between mean arterial pressure and weight/height/BMI. A p-value less than 0.005 is taken as statistically significant.

RESULTS

This study was conducted to find out the average value of mean arterial pressure among children aged 3-10 years. Review of literature showed limited studies for the normal ranges of MAP, though there are many studies for systolic and diastolic blood pressure.

A total of 502 children were included in this study, 54 % (272) were males and 46 % (230) were females. Most of the children (44%) in this study group belonged to 5-6 years of age. The mean age of the study population was 6 years. The mean weight was 18±5 kg. The mean height was 112±12 cm .The mean BMI was 14±2 kg/m^2. The mean MAP of male children in our study was as follows. 3-4 years (75±9 mmHg), 5-6 years (75±8 mmHg), 7-8 years (76±7 mmHg), 9-10 years (79±11 mmHg).

The mean MAP of female children in our study was as follows. 3-4 years (77±7 mmHg), 5-6 years (77±8 mmHg), 7-8 years (78±9 mmHg), 9-10 years (79±8

mmHg). On statistical analysis MAP has got a positive correlation with weight, height and BMI. There is no gender variation for mean arterial pressure. MAP of the study population in relation to age (Table 1), MAP of children in relation to weight (Table 2). MAP of boys in relation to height centiles (Table 3) and MAP of girls in relation to height centiles (Table 4) were tabulated as follows.

Table 1: Mean arterial pressure percentiles in relation to age.

Age (years)	N	Mean Arterial Pressure						
		P5	P10	P25	P50	P75	P90	P95
3 - 4	99	64	67	71	76	82	87	90
5 - 6	221	62	65	71	77	82	87	90
7 - 8	111	65	67	72	77	83	89	92
9 - 10	71	64	66	74	80	86	92	95

Table 2(a): Mean arterial pressure in relation to weight.

Weight (kg)	Mean	SD
10 - 15	75.19	7.931
16 - 20	76.53	8.672
21 - 25	79.98	10.59
> 25	81.11	7.805

Table 2(b): Mean arterial pressure percentiles of boys in relation to height and age.

Age (years)	Height (cm)	N	Mean Arterial Pressure						
			P5	P10	P25	P50	P75	P90	P95
3-4	Up to 100	34	56	64	69	72	78	84	86
	101 – 110	20	63	66	73	79	83	91	96
	111 – 120	1	68	68	68	68	68	68	68
	121 – 130	1	108	108	108	108	108	108	108
	> 130	0							
5-6	Up to 100	13	53	56	68	70	73	79	79
	101 - 110	60	62	65	70	76	82	86	89
	111 - 120	40	59	65	71	77	84	87	92
	121 - 130	4	76	76	76	80	88	88	88
	> 130	0							
7-8	Up to 100	2	77	77	77	82	82	82	82
	101 - 110	1	74	74	74	74	74	74	74
	111 - 120	19	54	65	69	76	86	90	90
	121 - 130	28	68	71	74	76	83	89	89
	> 130	6	66	66	66	73	82	82	82
9-10	Up to 100	0							
	101 - 110	0							
	111 - 120	2	52	52	52	68	68	68	68
	121 - 130	14	52	59	73	81	86	98	98
	> 130	27	65	68	74	80	87	93	103

Table 3: Mean arterial pressure percentiles of girls in relation to height and age.

Age (years)	Height (cm)	N	Mean Arterial Pressure						
			P5	P10	P25	P50	P75	P90	P95
3 – 4	**Up to 100**	20	62	65	71	76	83	89	90
	101 – 110	21	67	69	73	77	85	87	90
	111 – 120	2	82	82	82	85	85	85	85
	121 – 130	0							
	> 130	0							
5 – 6	**Up to 100**	17	64	64	70	76	83	90	90

Continued.

Age (years)	Height (cm)	N	Mean Arterial Pressure						
			P5	P10	P25	P50	P75	P90	P95
	101 – 110	54	62	67	74	78	83	88	91
	111 – 120	31	54	62	73	78	81	85	89
	121 – 130	2	82	82	82	90	90	90	90
	> 130	0							
7 – 8	**Up to 100**	0							
	101 – 110	5	70	70	72	84	88	88	88
	111 – 120	12	56	59	74	79	82	86	86
	121 – 130	30	65	69	72	76	87	94	103
	> 130	8	63	63	70	84	91	91	91
9 – 10	**Up to 100**	0							
	101 – 110	0							
	111 – 120	6	65	65	69	76	79	79	79
	121 – 130	9	72	72	75	82	91	91	91
	> 130	13	63	64	74	80	88	92	92

DISCUSSION

The early detection and rapid treatment of hypotension and hypertension are important in the management of critically ill and injured children. MAP is often used as a therapeutic end point in shock management. Thus, it is important to define the normal ranges of MAP in children. The data from our study indicate that there is slight increase in MAP according to age in both males and females. Even though this was statistically significant, there was overlap of confidence intervals. Two studies done with larger sample sizes in western population also reflect the same pattern. In a study of over 60,000 children by Ikram U Haque et al. and in another study of over 1 lakh children by De Graffe et al. MAP was observed to increase from 1-18 years.[3,4] Inspite of searching accessible medical literature, we could not find an Indian study which had looked into MAP directly. In a study done by Bose et al. amongst children aged 3-15 years in urban areas of Calcutta, the systolo-diastolic BP of children were looked into.[5] Their data is almost comparable to that of our systolo-diastolic BP, Although our children had slight elevation. For example, at 3 years of age male children in their study had SBP and DBP 96 mmHg and 62 mmHg respectively, whereas our corresponding values were 100 mmHg and 63 mmHg. Similarly, female children aged 3 years had a SBP and DBP of 95 mmHg and 62 mmHg respectively, whereas our corresponding values were 100 mmHg and 65 mmHg respectively.

Another interesting observation is that, in western studies children had lower MAP in comparison to Indian children of the same group. For example, a MAP of 79 mmHg was obtained at 9-10 years in our study, whereas in the study by De Graff et al., MAP at 18 years was only 65 mmHg.[4] The same difference can be seen in the study by Ikram et al. where children aged 9-10 years had 50th percentile MAP of 73 mmHg in comparison to MAP of 79 mmHg in our study population.[3] Hence we argue that Indian children may have an inherently higher MAP in respect to their western counterparts. Whether this has got long term implication will have to be ascertained in future studies.

The result of our study did not find gender based difference in MAP values (76±9 mmHg for males and 77±8 mmHg for females).Other studies by De Graff et al. and Banker Chirag et al. also show similar findings.[4,6]

A weak positive correlation was obtained for MAP and weight (r-0.229). Though we could not find a study which looked into the correlation of MAP and weight, a study done by Kamatham Madhusoodhanan et al showed a linear relation between systolo–diastolic BP and weight.[7]

A weak positive correlation was obtained in our data for MAP and height (r-0.192) .A study by Ikram et al. done over 60,000 children also showed a positive correlation of MAP and height.[3] But when compared to our data, the children in their study had a lower MAP for corresponding height centiles. This again shows that our children may have an inherently higher BP.

We found a weak positive correlation between BMI and MAP (r -0.178) .Similar finding was reported by Justin P Zachariah et al in a study based on children in US.[8] A study by Reddy et al. on school children aged 5-15 years also showed a positive correlation between BP and BMI.[9]

On comparing the correlation coefficients weight was found to have more positive correlation with MAP than height and BMI. MAP did not show any relationship with gestational age at birth.Children who were born preterm and term had comparable MAPs. (77±10 mmHg and 77±8 mmHg) respectively.

In a study on 1617 neonates by Moumita et al. it was seen that preterms have a lower MAP than term babies.[10] Also in a study by based on pregnant women in Canada done by Sutherland et al. it was seen that women who were

born preterm at birth had increased pregnancy induced hypertension as well as chronic hypertension.[11] This shows that children born preterm although have lower MAP when compared to their term counterparts they still might be at risk of hypertension in adult life. The influence of lifestyle factors might account for this as mentioned in Barker's hypothesis.

The 5th percentile of MAP in our study population ranged from 62-65 mmHg though not a primary objective of ours a cut off of < 60 mmHg can be used to diagnose hypotension in children. Similarly 95th percentile of MAP ranged from 90-95 mmHg. So a MAP based cut off > 95 mmHg can be used to define hypertension as well. The existent BP charts use Systolo-Diastolic BP for percentiles, not MAP. It has to be reiterated that our sample size could be insufficient to create percentile charts.

In conclusion the relationship between MAP and other anthropometric parametric variables in our study is in agreement with western studies. But our children show a trend towards higher MAP values in comparison to their western counterparts.

How the study advances knowledge and understanding

There is no gender variation for MAP.MAP of our study population is higher than that of western population which may be due to the dietary habits, in the form of excessive fast food consumption and sedentary lifestyles.

Limitations

The representation of children in various age groups were not equal in our data, hence there was limitation in calculating MAP based on height centiles. Considering this fact we were planning to include more number of children in this study, but due to the COVID Pandemic further collection of data was impossible.

CONCLUSION

The mean MAP of male children in our study was as follows, 3-4 years (75±9 mmHg), 5-6 years (75±8 mmHg), 7-8 years (76±7 mmHg), 9-10 years :-79±11 mmHg . The mean MAP of female children in our study was as follows, 3-4 years (77±7 mmHg), 5-6 years (77±8 mmHg), 7-8 years (78±9 mmHg), 9-10 years (79±8 mmHg). MAP was found to be highly correlated with weight, height and BMI, with a maximum positive correlation with weight.

Recommendations

Our recommendation is to include more number of children so that we can make a normogram which will be helpful in monitoring hemodynamic status of critically ill children. According to our study the blood pressure in our study population is higher than western population, so lifestyle modifications should be made for our children in the form of dietary modifications and exercise.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Naushad A, Anand M, Kumar S, Anand MR, Kumar SEK. The average value of mean arterial pressure among children aged 3-10 years as per age, gender and height centiles: A cross sectional study. Int J Contemp Pediatr 2023;10:1077-82.