Method Article

Mean Arterial Pressure classification: a better tool for statistical interpretation of blood pressure related risk covariates

ABSTRACT

Systolic blood pressure (SBP) and diastolic blood pressure (DBP) are both equally important to analyze the relations between blood pressure and its associated risk covariates. Quantitative analyses however, sometime provide separate results for SBP and DBP. It is more evident in people with systolic or diastolic hypertension. It sometime becomes difficult to interpret while performing statistical analyses. Mean arterial pressure (MAP) which is a time-weighted average of the arterial pressure over the whole cardiac cycle is a very useful tool for biological and medical science. But, till date in best of our knowledge, it has no classification like blood pressures. So, in this paper a classification of MAP was formulated following the blood pressure classification as recommended by World Health Organization (WHO) and European Society of Hypertension and European Society of Cardiology (ESH/ESC). The resultant value of MAP was then classified into several categories like, optimal, normal, high normal and so on. A researcher can use MAP classification for data analysis since, it will yield only one statistical result instead of two separate results (i.e. SBP and DBP) as to observe the relation of blood pressure (MAP) with different risk covariates. The vascular complications associated with hypertension include stroke, cardiovascular disease, chronic renal failure etc., require regular screening to avoid serious organ damage. Classification of MAP would therefore be more effective than blood pressure classifications not only in clinical practice but in public health as well. MAP classification would immensely help in translating large epidemiological data in to meaningful statistical interpretations. The present article is therefore an attempt to postulate the MAP classification as innovative method for better statistical analyses, screening and analyses in studies related to blood pressures and its associated risk covariates.

Keywords: Mean arterial pressure, Systolic blood pressure, Diastolic blood pressure, Mean arterial pressure classification, Cardiometabolic risk

INTRODUCTION

Hypertension is a major health problem throughout the world because of its high prevalence and its association with increased risk of cardiovascular disease. The World Health Organization has estimated that high blood pressure cause one in every eight deaths, making hypertension the third killer in the world [1]. Primary prevention is the most cost-effective approach to containing the emerging hypertension epidemic. Good management of hypertension is central to any strategy formulated to control hypertension at the community level. There are different types of health problem arise due to the cause of unconsciousness [2]. Nowadays, cardiovascular disease is an important subject matter of bio-medical science for the developing countries, because most of the people have either no or little consciousness about blood pressure; even they do not check their blood pressure in a regular interval [3]. Ultimately, the disease is not prevented; rather it increased abruptly. Recently reported that, in India the average age of heart patients is 52 years, it is very much higher compare to America where it is 70 years, as reported by American College of Cardiology [4]. It has been argued that a comprehensive surveillance system is important for the management of non-communicable

disease like hypertension [5]. There are so many measurements which can be taken from the individuals of a population to clarify physical health of that particular population; one of the important variables is blood pressure [6]. So collection of blood pressure and its proper analysis is one of the ways to find out populations health condition.

For this matter, authors have collected data about blood pressure (as dependent variables) as well as different anthropometric data (as independent variables), from Bengali speaking population of in and around Kolkata, West Bengal, India. Because, each individual have their specific blood pressure (SBP & DBP) which cannot follow together by any standard classification. It was very commonly found from this study that, an individual have normal systolic pressure (for example 120 mmHg) but diastolic pressure is high (for example 86 mmHg) or vice-versa, then it is very difficult to classified those individuals, because available blood pressure classification includes both SBP and DBP. But both Systolic and Diastolic blood pressures are equally important to analyze the relations between blood pressure and other factors [7]. These analyses create a problem specially to find out the relationship between blood pressure and other factors of a population.

Mean arterial pressure (MAP) is one of the important tools by which researcher can solved this particular problem because MAP is a time-weighted average of the arterial pressure over the whole cardiac cycle, which is calculated as the diastolic pressure plus one-third of the pulse pressure [8]. It gives a measure of the average perfusion pressure of the systematic circulation.

But MAP has no particular standard classification. For this matter researcher cannot classify the studied population in a compact way. For the above mentioned facts, the authors intend to formulate a ready-to-use classification of MAP with the help of internationally accepted blood pressure classification and the formula of MAP.

MATERIAL AND METHODS:

The present study has been conducted in four steps. First two steps include two fundamental tools, third and fourth steps are for formulating the classification.

A. Selection of a blood pressure classification
B. Selection of a formula of mean arterial pressure
C. Calculation of mean arterial pressure
D. Data collection and statistical analyses

A. *Selection of a blood pressure classification*

Classification of blood pressures as guided by the European Society of Hypertension and the European Society of Cardiology has taken in to consideration as it is an elaborate and standardize classification globally well accepted [9].

Table I. Classification of blood pressure

Category	Systolic pressure	Diastolic pressure
Optimal	<120	<80
Normal	120-129	80-84
High Normal	130-139	85-89
Grade 1 Hypertension (Mild)	140-159	90-99
Grade 2 Hypertension (Moderate)	160-179	100-109
Grade 3 Hypertension (Sever)	≥180	≥110
Isolated systolic hypertension	≥140	<90

From above mentioned classification all the categories are included except isolated systolic hypertension. Because, it has no particular cut off point; systolic pressure include ≥140 and diastolic pressure include <90. It was observed that if isolated systolic hypertension included in the analysis then, blood pressure values fluctuating abruptly at the time of calculation of checker-board. Hence, checker-board does not include isolated systolic hypertension. From the different category of blood pressure classification, only maximum cut off values are includes in the checker board. For systolic blood pressure values are 120, 129, 139, 159, 179 and 180 on the other hand diastolic blood pressures includes 80, 84, 89, 99, 109 and 110; both values are conducted for Optimal, Normal, High normal, Grade 1, Grade 2 and Grade 3 hypertension respectively. Another widely used classification of blood pressures were studied as guided by World Health Organization (WHO) [7].

B. *Selection of a formula of mean arterial pressure.*

Another necessary tool is the formula of mean arterial pressure (MAP). Mean arterial pressure is not a simple arithmetic average of the diastolic and systolic blood pressures because the arterial blood spends relatively longer near the diastolic pressure than the systolic blood pressure. The mean arterial pressure is directly proportional to cardiac output. For the most working purpose, an approximation to mean arterial pressure can be obtained by applying the following simple equation [8]:

$$\text{Mean Arterial Pressure} = \text{Diastolic Pressure} + \left(\frac{1}{3} \times \text{Pulse Pressure}\right)$$

Pulse Pressure (mmHg) is the difference between systolic and diastolic blood pressures, formula of the pulse pressure is written as:

$$\text{Pulse Pressure} = (\text{Systolic Blood Pressure} - \text{Diastolic Blood Pressure})$$

C. *Calculation of mean arterial pressure*

Mean arterial pressure formulate by the help of previously mentioned or selected blood pressure classification and MAP formula. However, the calculation of mean arterial pressure can be done through following way:

Blood Pressure Category	Blood Pressure Value (mmHg)		Pulse Pressure (mmHg)	MAP value (mmHg)
	SBP	DBP		
Optimal	120	80	40	93.33
Normal	129	84	45	99.00
High Normal	139	89	50	105.67
Grade 1 Hypertension	159	99	60	119.00
Grade 2 Hypertension	179	109	70	132.33
Grade 3 Hypertension	180	110	70	133.33

The above mentioned equation elaborately considered in a checker-board. It is called 'MAP checker-board', this terminology has been used for the ongoing analysis of MAP classification. The MAP

checker-board obtained by the following process. At first the maximum value of systolic pressure was entered serial-wise in the left side in the checker-board; maximum value of diastolic pressure was entered serial-wise in the top of the checker board; the MAP was then calculated as the standard equation and entered into the appropriate cell. For example, if the systolic blood pressure is 120 mmHg and the diastolic blood pressure is 80 mmHg, then MAP = [80 + {1/3 × (120-80)}] or 93.33 mmHg as given in the following table.

Table II. MAP - Checker Board

Category			Diastolic Pressure (mmHg)					
			Optimal	Normal	High normal	Grade 1	Grade 2	Grade 3
			80	84	89	99	109	110
Systolic Pressure (mmHg)	Optimal	120	93.33	96	99.33	106	112.67	113.33
	Normal	129	96.33	99	102.33	109	115.67	116.33
	High normal	139	99.67	102.33	105.67	112.33	119	119.67
	Grade 1	159	106.33	109	112.33	119	125.67	126.33
	Grade 2	179	113	115.67	119	125.67	132.33	133
	Grade 3	180	113.33	116	119.33	126	132.67	133.33

It is very easy to calculate the mean arterial pressure value from any standard blood pressure classification by the help of mean arterial pressure formula. After the formulation of checker board, classification of MAP was performed. MAP classification is applicable to any recommended blood pressure classification like WHO etc.

D. *Data collection and statistical analyses*

The present study was conducted on 500 adult (≥ 30 yrs) Bengali speaking population living in and around Kolkata, India which include 257 males and 243 females. Anthropometric measures like height, weight, waist circumference, hip circumference were measured as per standard techniques [10]. Body mass Index was computed as weight (in kg) divided by height squared (in cm). Blood pressures (both systolic and diastolic) were measured twice by means of aneroid sphygmomanometer and stethoscope twice in sitting posture over right arm and the average was considered for analyses. A third measurement was taken if the difference between two measurements were ≥ 5mm/Hg. MAP was calculated as discussed earlier. The Institutional Ethics Committee of the West Bengal State University, Barasat, India has had approved the study. Written consent from participants was also obtained prior to actual commencement of the study.

All the statistical analyses were performed on SPSS (Version14.0). A statistical significance was set at $p<0.05$ (two-tailed) for all analyses.

RESULTS AND DISCUSSION

The Mean Arterial Pressure checker-board shows different MAP values, from which some values are used for MAP classification. In case of the formulation of MAP classification mainly used those particular values which are crossed by the same category of both systolic and diastolic blood pressure. Unfortunately, those MAP values are always similar or greater than the pick value of any one of the crossed category. This matter is one of the supporting issue to the researcher for create a category of mean arterial pressure. Here MAP values considered as up to two decimal. The explanations of MAP classification are given below:

- Optimal MAP value is <93.33; because optimal blood pressure contain SBP value less than 120 and DBP value less than 80, so optimal MAP value is less than 93.33.

- Normal MAP values are 93.33 to 99.00; since normal blood pressure contains the value of SBP 120 to 129 and DBP 80 to 84, so normal MAP value is 93.33 to 99.00.

- High Normal MAP values are 99.01 to 105.67; as the high normal blood pressure value started just after the value of highest value of normal blood pressure, on the other hand highest value for high normal blood pressure contain SBP 139 and DBP 89, so high normal MAP value is 99.01 to 105.67.

- Grade 1 Hypertension (Mild) MAP values are 105.68 to 119.00; same as high normal blood pressure the lowest value begins after the highest value of high normal value up to the highest value of grade 1 hypertension, so the MAP value for Grade 1 Hypertension (Mild) is 105.68 to 119.00.
- Grade 2 Hypertension (Moderate) MAP valuesare119.01 to 132.33; similarly, the lowest value begins after the highest value of grade 1 hypertension value up to the highest value of grade 2 hypertension, so the MAP value for Grade 2 Hypertension (Moderate) is 119.01 to 132.33.

- Grade 3 Hypertension (Severe) MAP values are above 132.33; it has no doubt that the value grade 3 hypertension included the higher value than the maximum value of grade 2 hypertension, so the value of grade 3 hypertension is ≥132.34.

Finally, from the above clarification the following classification of Mean Arterial Pressure has been formulated:

Table III. Classification of MAP

Category	MAP (mmHg)
Optimal	<93.33
Normal	93.33 - 99.00
High Normal	99.01 - 105.67
Grade 1 Hypertension (Mild)	105.68 - 119.00
Grade 2 Hypertension (Moderate)	119.01 - 132.33
Grade 3 Hypertension (Sever)	≥132.34

It was found that MAP was a better predictor of blood pressure associated risk covariates like BMI, WC etc as compare to SBP and DBP separately. The table below shows the correlation coefficient and multiple regression (stepwise) with blood pressure as dependent and BMI & EC as independent variables.

Table IVa: Correlation coefficient between blood pressure and adiposity measures

Correlation	WC (p value)	BMI (p value)
MAP	0.427 (0.0001)	0.404 (0.0001)
SBP	0.426 (0.0001)	0.399 (0.0001)
DBP	0.349 (0.0001)	0.332 (0.0001)

Table IVb: Multiple regression (stepwise) with blood pressure measures as dependent and adiposity measures as independent variables

Regression	B	R^2change	t value	p value
MAP	0.427	0.182	7.153	0.0001
SBP	0.576	0.182	7.147	0.0001
DBP	0.349	0.122	5.644	0.0001

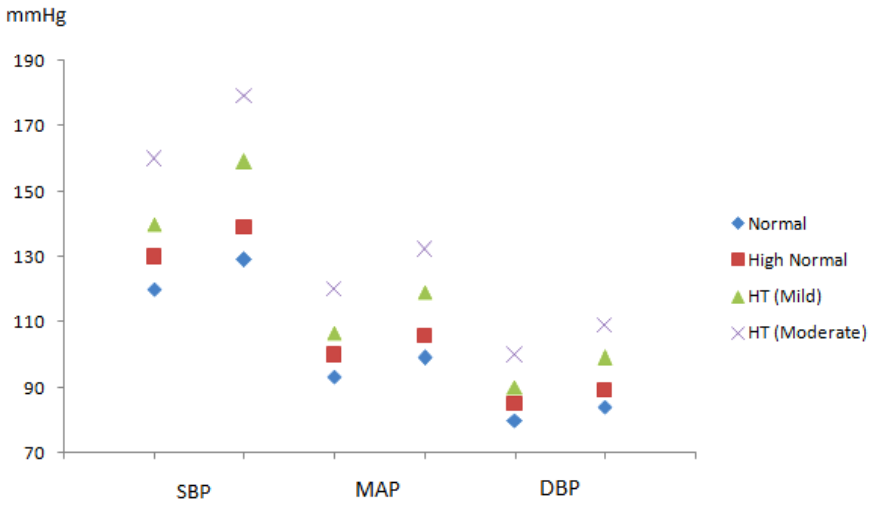

Figure 1: Classification of MAP in association with SBP and DBP

It clearly indicates that MAP is a better indicator for analytical interpretation as compare to SBP and DBP separately as it yields different results. MAP is significantly correlated with adiposity measures as SBP and DBP. Moreover, the stepwise regression analyses shows that the MAP is no less significant that SBP and DBP. The R^2change for SBP and MAP are same but not DBP thereby indicating that MAP could be used as the representative variable for blood pressure in place of SBP and DBP separately.

CONCLUSION

Actually Mean Arterial Pressure (MAP) is the intermediate between SBP and DBP. MAP is considered to be the perfusion pressure of the body. So it can be easily understood that this classification is very useful, which can help researchers to calculate different quantitative analysis particularly for inferential statistics. As well as by the help of this classification a blood pressure compactly used as independent variable, where no need to maintain SBP and DBP separately. Most of the cases researchers are found that a same person have two different types of blood pressure, such as systolic pressure is normal other hand diastolic pressure is higher or vice versa. Then the researcher cannot classify that particular person within a single term or value. On the other hand, MAP classification could be very useful in a large population when a researcher would like to know about the overall scenario of the blood pressure, such as percentage analysis of that particular population; how many people have normal blood pressure or how many people have high blood pressure as well as to find out the variation in blood pressure between two or more populations.

It is however, reasonable to mention that separately both SBP and DBP are important in case of clinical purpose or medical treatment rather than MAP. Researcher cannot apply this classification to the study about isolated systolic hypertension since it has no particular cut off value. MAP would

therefore seems to be very useful for the purpose of statistical analyses important for both clinical as well as large scale epidemiological studies which includes, blood pressures and its association with other risk covariates like cardiovascular diseases, coronary heart disease, type 2 diabetes etc. for better analyses, interpretation and preventive purposes.

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