Speaking for Myself

Defining Hypertension in the Indian Population

RAJEEV GUPTA

INTRODUCTION

High blood pressure (BP) has been defined in the past according to the World Health Organization (WHO) criteria as systolic BP ≥160 mmHg and/or diastolic BP ≥95 mmHg.[1] However, more liberal criteria for diagnosis were adopted when many studies established that a BP lower than the WHO cut-off was important in the genesis of cardiovascular disease. Guidelines published by the Fifth US Joint National Committee (JNC-V),[2] the European Working Group on Hypertension[3] and the WHO[1] recommend lower BP levels for diagnosis and initiation of therapy (Table I).

These values are based on prospective population studies in developed countries. Studies from developing countries show that the mean BP of the population is lower as compared to that in developed countries.[4,5] Therefore, the population norms as well as values above which a high BP causes vascular risk could be lower in these countries. Another important limitation of the JNC-V guidelines is that the classification is uniformly applicable to all adults (>18 years). Studies have shown that there is a gradual increase in BP with age. Therefore, the hypertension level should be different for different age groups.

We performed epidemiological studies on hypertension in western Indian urban and rural cohorts.[6–9] One thousand four hundred and fifteen out of 1609 eligible men (87.9%) and 797 of 1391 eligible women (57.3%) from urban areas and 1982 of 2188 eligible men (90.6%) and 1166 of 1968 eligible women (59.2%) from rural areas were examined. The supine BP was measured using a standard mercury sphygmomanometer.[1] The prevalence of hypertension was greater in urban (men 30%, women 33%) compared to rural (men 24%, women 17%) subjects.

MEAN BLOOD PRESSURE

In the overall population (n=5360), the mean systolic BP was 126±15 mmHg and the diastolic BP 81±9 mmHg. The median values for systolic and diastolic BP were lower than the means, suggesting a positive skew of the distribution of BP (Table II). The frequency distribution of systolic and diastolic BP (Fig. 1) shows a positive skew of the standard normal curve. The distribution of means, medians and the 60th to 95th percentile values of systolic and diastolic BP in rural and urban men and women are shown in Tables III to VI. Age group-specific systolic and diastolic BP values are also provided. There is a significant increase in both systolic and diastolic BP with age in all the four groups ($p<0.0001$).

The increase in BP levels with age was confirmed by correlational analysis. There were significant r values for both systolic and diastolic BP in rural and urban men and women (r: systolic BP 0.27–0.41; diastolic BP 0.25–0.35; $p<0.001$). Variance of BP (r^2) with age was also significant in all the four groups (systolic BP 0.08–0.17; diastolic BP 0.06–0.12; $p<0.001$). Regression analysis confirmed the significant association of BP with age. Regression coefficient (b) values were positive in all the four groups and showed that there was an increase in systolic BP by 3.6±0.1 mmHg and in diastolic BP by 1.7±0.1 mmHg with each decadal increase in age (Table II).

TABLE I. Classification of hypertension according to JNC-V recommendations[2]

Category	Systolic (mmHg)	Diastolic (mmHg)
Normal	<130	<85
High normal	130–139	85–89
Hypertension		
Stage 1 (mild)	140–159	90–99
Stage 2 (moderate)	160–179	100–109
Stage 3 (severe)	180–209	110–119
Stage 4 (very severe)	>210	> 120

JNC-V Fifth US Joint National Committee

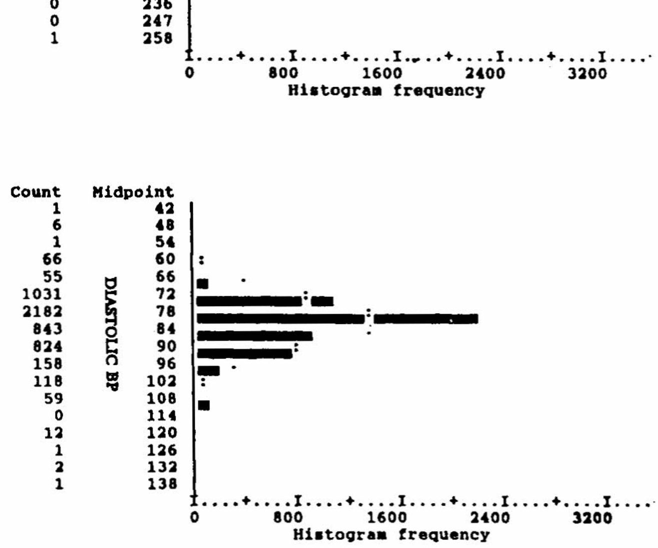

FIG 1. Frequency histogram showing distribution of systolic and diastolic BP in the study population. There is positive skew in both the curves.

Department of Medicine, Monilek Hospital and Research Centre, Jaipur 302004, Rajasthan, India

TABLE II. Blood pressure means, medians and percentiles in the total sample (n=5360)

Age group	n	Mean ±SD	+1SD	+2SD	Skew	Median	Percentiles 60	70	75	80	90	95
Systolic BP												
20–29	1615	120±11	131	142	1.62±0.1	120	120	122	126	128	130	130
30–39	1368	123±12	135	147	1.24±0.1	120	126	130	130	130	136	140
40–49	972	127±15	142	157	1.10±0.1	128	130	130	132	138	140	159
50–59	757	133±18	151	169	0.86±0.1	130	136	140	140	150	156	160
60–69	442	133±21	154	175	1.56±0.1	130	130	140	140	150	160	170
70+	206	135±26	161	187	0.53±0.2	130	138	142	150	160	170	180
		ANOVA F=140.1; r=0.33, r^2=0.11; b=3.48±0.14; p<0.0001										
Diastolic BP												
20–29	1615	77±6	83	89	0.36±0.1	78	80	80	80	82	85	90
30–39	1368	80±8	88	96	0.46±0.1	80	80	82	84	86	90	92
40–49	972	82±9	91	100	0.55±0.1	80	84	86	88	90	92	96
50–59	757	84±10	94	104	0.49±0.1	84	88	90	90	90	96	100
60–69	442	84±10	94	104	0.91±0.1	82	84	90	90	90	96	100
70+	206	84±10	94	104	0.22±0.2	83	90	90	90	90	100	100
		ANOVA F =104.7; r=0.28, r^2=0.08; b=1.71±0.08; p<0.0001										

TABLE III. Blood pressure in rural men (n=1982)

Age group	n	Mean ±SD	+1SD	+2SD	Skew	Median	Percentiles 60	70	75	80	90	95
Systolic BP												
20–29	571	122±9	131	140	2.39±0.1	120	124	126	128	128	130	130
30–39	495	125±11	136	147	1.75±0.1	126	126	130	130	130	136	140
40–49	366	129±11	142	155	1.47±0.1	128	130	130	132	138	140	156
50–59	268	130±16	146	162	1.54±0.2	128	130	132	138	140	148	160
60–69	204	133±20	153	173	2.32±0.2	130	130	137	140	140	156	180
70+	78	134±20	154	174	1.26±0.3	130	136	140	140	141	160	186
		ANOVA F=36.7; r=0.29, r^2=0.08; b=2.71±0.20; p<0.0001										
Diastolic BP												
20–29	571	78±6	84	90	−0.24±0.1	78	80	80	82	84	86	90
30–39	495	81±7	88	95	0.29±0.1	80	82	84	84	86	90	92
40–49	366	83±9	92	101	0.35±0.1	84	84	88	90	90	94	98
50–59	268	83±9	92	101	0.36±0.1	83	84	88	90	90	94	100
60–69	204	84±10	94	104	1.08±0.2	82	84	86	90	90	95	105
70+	78	84±9	93	102	0.42±0.3	84	86	90	90	92	94	101
		ANOVA F=31.1; r=0.25, r^2=0.06; b=1.34±0.12; p<0.0001										

TABLE IV. Blood pressure in urban men (n=1415)

Age group	n	Mean ±SD	+1SD	+2SD	Skew	Median	Percentiles 60	70	75	80	90	95
Systolic BP												
20–29	526	119±12	131	143	1.53±0.1	120	120	120	120	126	130	140
30–39	374	123±13	136	149	1.12±0.1	120	126	130	130	130	136	150
40–49	183	129±17	146	163	0.97±0.2	130	130	130	140	140	150	164
50–59	211	135±19	154	173	0.51±0.2	132	140	147	150	150	160	160
60–69	72	134±20	154	174	1.14±0.3	130	140	150	150	150	160	163
70+	40	139±22	151	173	0.27±0.3	140	140	160	160	160	170	180
		ANOVA F=52.3; r=0.39, r^2=0.15; b=4.56±0.29; p<0.0001										
Diastolic BP												
20–29	526	77±7	84	91	0.44±0.1	80	80	80	80	80	86	90
30–39	374	80±8	88	96	0.47±0.1	80	80	80	84	86	90	90
40–49	183	83±10	93	103	1.26±0.2	80	84	89	90	90	92	100
50–59	211	86±10	96	106	0.60±0.2	86	90	90	90	90	96	100
60–69	72	84±10	94	104	1.02±0.3	80	90	90	90	90	94	97
70+	40	84±10	94	104	−0.33±0.3	86	90	90	90	90	100	100
		ANOVA F=36.8; r=0.31, r^2=0.10; b=2.01±0.16; p<0.0001										

TABLE V. Blood pressure in rural women (n=1166)

Age group	n	Mean ±SD	+1SD	+2SD	Skew	Median	Percentiles 60	70	75	80	90	95
Systolic BP												
20–29	382	119±9	128	137	1.45±0.1	120	120	122	126	126	130	130
30–39	342	124±11	135	146	1.43±0.1	122	126	128	130	130	136	140
40–49	212	127±15	142	157	1.96±0.2	126	130	130	130	136	140	160
50–59	127	130±18	148	166	1.51±0.2	126	130	130	136	140	150	176
60–69	80	127±17	144	161	2.05±0.3	128	128	130	136	136	140	160
70+	23	134±19	153	172	0.39±0.5	130	138	140	146	152	166	170
		ANOVA F=21.4; r=0.27, r^2=0.07; b=2.70±0.28; p<0.0001										
Diastolic BP												
20–29	382	77±6	83	89	1.29±0.1	76	76	78	80	80	84	90
30–39	342	79±7	86	93	0.55±0.1	78	80	82	84	84	90	92
40–49	212	81±8	89	97	0.63±0.2	80	82	84	84	88	90	98
50–59	127	83±9	92	101	0.42±0.2	82	84	87	89	90	96	98
60–69	80	81±8	89	97	0.35±0.3	81	84	84	86	90	90	96
70+	23	85±11	96	107	0.40±0.4	84	90	90	90	95	100	108
		ANOVA F=20.1; r=0.27, r^2=0.07; b=1.52±0.16; p<0.0001										

TABLE VI. Blood pressure in urban women (n=797)

Age group	n	Mean ±SD	+1SD	+2SD	Skew	Median	Percentiles 60	70	75	80	90	95
Systolic BP												
20–29	136	115±12	127	139	2.00±0.2	115	120	120	120	120	122	130
30–39	157	117±15	142	157	−2.40±0.2	118	120	120	125	128	130	140
40–49	211	124±15	139	154	0.17±0.2	124	130	130	130	140	140	150
50–59	151	137±21	158	179	0.13±0.2	140	150	150	150	150	160	170
60–69	86	139±23	162	185	0.27±0.3	140	150	150	160	160	170	177
70+	56	132±27	159	186	0.30±0.3	125	142	150	158	160	170	172
		ANOVA F=47.2; r=0.41, r^2=0.16; b=5.41±0.44; p<0.0001										
Diastolic BP												
20–29	136	75±8	83	91	−1.83±0.2	80	80	80	80	80	80	86
30–39	157	78±10	88	98	−0.49±0.1	80	80	80	80	82	90	92
40–49	211	79±8	87	95	−0.55±0.2	80	80	80	84	86	90	90
50–59	151	86±12	98	110	0.30±0.2	90	90	90	90	90	100	110
60–69	86	87±12	99	111	0.56±0.3	88	90	90	90	90	102	110
70+	56	83±11	94	105	0.42±0.3	80	81	90	90	90	100	101
		ANOVA F=30.3; r=0.33, r^2=0.11; b=2.37±0.24; p<0.0001										

An analysis of rural–urban differences in BP levels showed that there were no significant differences in either systolic BP (men: rural 127±14, urban 125±17; women: rural 124±13, urban 126±18) or diastolic BP (men: rural 81±8, urban 81±9; women: rural 80±8, urban 81±12). Age-specific BP levels showed that in urban men the systolic BP was more in the age groups 50–59, 60–69 and ≥70 years. In urban women systolic BP was more in the age groups 50–59 and 60–69 years. The mean diastolic BP was significantly more in urban men aged 40–49 years and urban women aged 50–59 and 60–69 years as compared to that in rural subjects. Analysis of age group-specific gender differences showed that the systolic BP was more in men in the age groups 20–29, 30–39 and 40–49 years but was more in women in the age groups 50–59, 60–69 and ≥70 years. The diastolic BP levels were not significantly different.

MEDIANS AND PERCENTILES

An analysis of skewness of BP distribution curves showed a positive skew at all age groups which was confirmed by greater medians than means (Table II). The percentile distribution was, therefore, determined. For systolic BP, medians were less than 140 mmHg in all age groups (Table II); therefore, medians were not appropriate for the diagnosis of hypertension. Percentile values were different in the various age groups where systolic BP was ≥140 mmHg. In men aged 20–29 years this value was not reached until the 95th percentile while at 60–69 years it was achieved at the 70th percentile. Similar variations were seen in diastolic BP. If the 70th percentile was considered abnormal for systolic BP, hypertension is defined in age groups 50–59, 60–69 and ≥70 years. The corresponding values at age groups 20–29, 30–39 and 40–49 were 122, 130 and 132 mmHg, respectively. For diastolic BP, hypertension defined by the 70th percentile in age groups 50–59, 60–69 and ≥70 years, and the corresponding values for age groups 20–29, 30–39 and 40–49 years were 80, 82 and 86 mmHg, respectively. Thus, the statistical analysis showed that either percentile values for diagnosis of hypertension should be different at various age groups or the systolic/diastolic BP for the diagnosis of hypertension should be lower in younger subjects.

COMMENT

Hypertension experts are still undecided about the level of BP which should be considered abnormal. A great deal of effort has been made to search for a dividing line between normotension and hypertension. The suggested dividing lines were 120/80 in 1939, 130/80 in 1942, 140/90 in 1948, 150/90 in 1952, 160/100 in 1946 and 180/100 in 1948.[10] Uniformity was achieved after publication of the WHO report on proper measurement techniques of BP and criteria for the diagnosis of hypertension in 1959, after which systolic BP ≥160 mmHg and/or diastolic BP ≥95 mmHg were considered abnormal.[11]

Pickering for many years challenged the wisdom of that debate and decried the search for an arbitrary dividing line between normal and high BP.[10,12] In 1972 he restated his argument, 'There is no dividing line. The relationship between arterial pressure and mortality is quantitative; the higher the pressure, the worse the prognosis.' He viewed 'arterial pressure as a quantity and the consequence numerically related to the size of that quantity'.[10] Rose defines it as 'the operational definition of hypertension is the level at which the benefits of action exceed those of inaction'.[13] Kaplan states that criteria for diagnosis of hypertension should be established on some rational basis that includes the risks of disability and death associated with various levels of BP, as well as the ability to reduce those risks by lowering the BP.[14] He defines hypertension as 'that level of BP at which benefits (minus the risks and costs) of action exceed the risks and costs (minus the benefits) of inaction'. The benefits are: reduced risk of cardiovascular disease, debility and death; decreased monetary costs of catastrophic events; preservation of non-patient role; maintenance of current lifestyle and quality of life; avoidance of risks and side-effects of drug therapy; and avoidance of monetary costs of routine health care. The risks and costs are: psychological burden of the hypertensive patient; interference with quality of life and changes in lifestyle; risk, costs and side-effects of drug therapy.

A systolic BP ≥140 mmHg and diastolic BP ≥90 mmHg has been shown to be associated with increased cardiovascular risk in prospective cohort and case–control studies in the USA and Europe.[15,16] The Framingham study reported that there was a continuum of risk of stroke and coronary heart disease with increasing diastolic BP and the levels where risks were not present were unknown.[16] Stamler analysed the US studies of correlation of BP levels with cardiovascular risks and showed that both systolic and diastolic BP have a continuous, graded, strong, independent, aetiologically significant relationship to outcome variables such as cardiovascular mortality and all-cause mortality.[15] The Treatment of Mild Hypertension Study (TOMHS) showed that lowering of mildly raised BP (JNC-V Stage I) by drugs was associated with an improved outcome compared to a placebo group.[17] The cohort study was 45 to 64 years of age and the results may not be applicable to younger individuals. In the Multiple Risk Factor Intervention Trial (MRFIT) there was an excess of mortality at a systolic BP >110 mmHg although statistical significance was achieved at a BP of >120 mmHg.[15] The MRFIT data showed that these correlations were seen in younger individuals also. Stamler commented that an average systolic BP of 110 mmHg for the population is a realistic goal.[15] Our study also suggests that the BP norms should be lower than those currently recommended, especially in younger subjects.

No prospective studies similar to the Framingham or MRFIT exist in India. Thus, the levels of BP where the risk of cardiovascular events increase are not well defined.[5] The stroke mortality is high in China and Japan. The average BP levels in China are slightly lower than those in the present study. The mean BP levels were: systolic 118.6±18 mmHg and diastolic 76.6±11 mmHg in a sample of 10 076 urban and rural subjects between 35 and 54 years of age.[18] The high rate of stroke in the Chinese at low BP levels suggests that the level at which hypertension is defined should be lower. In sub-Saharan Africa stroke is a major public health problem although the prevalence of hypertension according to the older WHO criteria is only 6.6% in men and 7.5% in women.[19] In the Japanese cohort of the Seven Countries Study the frequency of diastolic hypertension (≥95 mmHg) increased from 8% in 1958 to 20% in 1982 and declined to 13% in 1989.[20] Although the stroke rate in this Japanese cohort decreased from 64/1000 person-years to 37/1000 person-years during this period, these findings suggest that hypertension should be diagnosed at lower BP levels in developing countries.

The population with hypertension has a bimodal distribution. The frequency distribution curve shows two peaks, an initial peak representing normal individuals and a smaller second peak representing hypertension. Our data (Fig. 1) also shows similar peaks in systolic and diastolic BP. Based on this distribution, Platt considered hypertension a genetic disorder, the initial peak representing normotensive individuals and the second peak those genetically prone to hypertension.[21] However, Pickering argued that BP was a continuous variable which is positively skewed towards higher values and his interpretation supported the commonly held view that hypertension was largely environmental.[12] Harrap opined that BP distribution curves show that genotype and environment interact to produce the BP phenotype.[21] Migration studies or changes in geographically stable populations over time provide persuasive evidence for the environmental effects. Dash *et al.* studied tribal populations in Orissa, who typically have a very low prevalence of hypertension, and showed that those who migrated to cities had a higher prevalence compared to those who did not.[22,23] These studies show the importance of changes in climatic, geographic, socio-economic, dietary and other lifestyle factors which lead to changes in the BP distribution of a population. Our data show that although BP levels are similar in urban and rural Indian populations, a higher prevalence of hypertension in the urban compared to the rural group indicates a skewness towards the upper end of BP distribution. This finding reflects the importance of environmental factors in the genesis of hypertension in urban Indians since genetically both rural and urban groups are similar. This finding has important preventive and therapeutic implications. Thus, environmental manipulation and changes in lifestyle risk factors can be applied to urban Indian subjects to reduce the increasing prevalence of hypertension.

REFERENCES

1 World Health Organization. Hypertension control: Report of a WHO Expert Committee. *WHO Tech Rep Ser* 1996;**862**:1–83.
2 Joint National Committee: The fifth report of the Joint National Committee on detection, evaluation and treatment of high blood pressure (JNC V). *Arch Intern Med* 1993;**153**:154–83.
3 Whelton PK. Epidemiology of hypertension. *Lancet* 1994;**344**:101–6.
4 Nissinen A, Bothig S, Granroth H, Lopez AD. Hypertension in developing countries. *World Health Stat Q* 1988;**41**:141–54.
5 Gupta R, Al-Odat NA, Gupta VP. Hypertension epidemiology in India: Meta-analysis of fifty year prevalence rates and blood pressure trends. *J Hum Hypertens* 1996;**10**:465–72.
6 Gupta R, Sharma AK. Prevalence of hypertension and sub-types in an Indian rural population: Clinical and electrocardiographic correlates. *J Hum Hypertens* 1994; **8**:823–9.
7 Gupta R, Gupta S, Gupta VP, Prakash H. Prevalence and determinants of hypertension in the urban population of Jaipur in western India. *J Hypertens* 1995;**13**:1193–200.
8 Gupta R, Gupta VP, Ahluwalia NS. Educational status, coronary heart disease, and

coronary risk factor prevalence in a rural population of India. *BMJ* 1994;**307**: 1332–6.
9 Gupta R, Prakash H, Majumdar S, Sharma SC, Gupta VP. Prevalence of coronary heart disease and coronary risk factors in an urban population of Rajasthan. *Indian Heart J* 1995;**47**:331–8.
10 Pickering G. Hypertension: Definitions, natural histories and consequences. *Am J Med* 1972;**52**:570–83.
11 World Health Organization. Hypertension and coronary heart disease: Classification and criteria for epidemiological studies. First report of the expert committee on cardiovascular diseases and hypertension. *WHO Tech Rep Ser* 1959;**168**:1–28.
12 Pickering G. The nature of essential hypertension. *Lancet* 1959;**2**:1027–8.
13 Rose G. Sick individuals and sick populations. *Int J Epidemiol* 1985;**14**:32–8.
14 Kaplan NM. Hypertension in the population at large. In: Kaplan NM. *Clinical hypertension.* Baltimore:William & Wilkins, 1994:1–22.
15 Stamler J, Stamler R, Neaton JD. Blood pressure, systolic and diastolic, and cardiovascular risks: US population data. *Arch Intern Med* 1993;**153**:598–615.
16 Collins R, MacMahon S. Blood pressure, antihypertensive drug treatment and the risks of stroke and of coronary heart disease. *Br Med Bull* 1994;**50**:272–98.
17 Neaton JD, Grimm RH, Prineas RJ, Stamler J, Grandits GA, Elmer PJ, *et al.* Treatment of Mild Hypertension Study (TOMHS): Final results. *JAMA* 1993;**270**: 713–24.
18 People's Republic of China–United States Cardiovascular and Cardiopulmonary Epidemiology Research Group. An epidemiological study of cardiovascular and cardiopulmonary disease risk factors in four populations in the People's Republic of China. *Circulation* 1992;**85**:1083–96.
19 Walker RW, McLarty DG. Hypertension and stroke in developing countries. *Lancet* 1995;**346**:778.
20 Koga Y, Hashimoto R, Adachi H, Tsuruta M, Tashiro H, Toshima H. Recent trends in cardiovascular disease and risk factors in the Seven Countries Study: Japan. In: Toshima H, Koga Y, Blackburn H, Keys A (eds). *Lessons for science from the Seven Countries Study.* Tokyo:Springer-Verlag, 1994:63–74.
21 Harrap SB. Hypertension: Genes versus environment. *Lancet* 1994;**344**:169–71.
22 Dash SC, Swain PK, Sundaram KR, Malhotra KK. Hypertension epidemiology in an Indian tribal population. *J Assoc Physicians India* 1986;**34**:567–70.
23 Dash SC, Sundaram KR, Swain PK. Blood pressure profile, urinary sodium and body weight in the Oraon rural and urban tribal community. *J Assoc Physicians India* 1994;**42**:878–80.

Obituaries

Many doctors in India practise medicine in difficult areas under trying circumstances and resist the attraction of better prospects in western countries and in the Middle East. They die without their contributions to our country being acknowledged.

The National Medical Journal of India wishes to recognize the efforts of these doctors. We invite short accounts of the life and work of a recently deceased colleague by a friend, student or relative. The account in about 500 to 1000 words should describe his or her education and training and highlight the achievements as well as disappointments. A photograph should accompany the obituary.

—*Editor*