

STUDY OF THE ACCURACY OF SPHYGMOMANOMETERS IN A TEACHING HOSPITAL

Jamal ud Din, Zahidullah Khan, Shafaq Naz

Department of Medicine, Khyber Teaching Hospital, Peshawar, Pakistan

ABSTRACT

Background: Defects or inaccuracy of sphygmomanometers may be the source of error in the diagnosis of hypertension. In this study we examined the physical condition and accuracy of sphygmomanometers used in various units of a teaching hospital.

Material & Methods: This study was conducted at Khyber Teaching Hospital, Peshawar, including both wards and out patient departments from July, 2008 to January, 2009. We tested the accuracy and physical condition of 100 consecutively available sphygmomanometers. A test manometer was defined as being intolerant if it deviated from the new, standard manometer by greater than ± 3 mmHg at 2 or more of the test pressure levels.

Results: Out of 100 sphygmomanometers, 62 were collected from 15 different wards and 38 from the Out Patient Departments. Forty-six (46%) of these showed deviation from the new mercury manometer by greater than ± 3 mmHg at two or more of the test points. Regarding physical defects there were defective pump bulbs in (60%), defective rubber tubing (38%), and mercury level not pointing to the zero in (37%). Thirty-four (55%) of the 62 ward sphygmomanometers and 12 (32%) of the 38 OPD sphygmomanometers were intolerant. In total, 46 (46%) of the 100 test sphygmomanometers were intolerant. There were faults in the inflation-deflation system of 46 (46%) sphygmomanometers. There was leakage in system of 34 (34%) sphygmomanometers.

Conclusion: The functional and physical conditions of sphygmomanometers used in our set up are insufficient and defective. Sphygmomanometers in use should be regularly assessed.

Key words: Blood Pressure, Sphygmomanometer, Calibration.

INTRODUCTION

Hypertension is defined in an adult as a blood pressure (BP) $\geq 140/90$ mmHg.¹ Hypertension can occur at any age, but it is more common among adults and often goes unnoticed.² The appropriate treatment of hypertension requires an accurate diagnosis and it is essentially diagnosed by measuring the BP. Indirect blood pressure measurement using sphygmomanometers with auscultatory method is a routine procedure in the diagnosis of hypertension. Therefore the accuracy of the values obtained is essential, since errors may deprive hypertensive patients of the benefits of treatment and expose normotensive persons to unnecessary treatment.³⁻⁷

Sphygmomanometer is one of the important components in the BP measurement. Aneroid sphygmomanometers are used commonly in primary care setting in our country and are less accurate and less reliable than mercury sphygmomanometers.²⁰

Many technical errors might occur related to the equipment used in routine indirect BP measurement and influence the reading. There are numerous reports on the condition of sphygmomanometers in general hospitals and family practice, showing that as many as half of these may be defective.⁸⁻¹²

This study was conducted to examine the physical condition and accuracy of sphygmomanometers used in various units of a teaching hospital at Peshawar.

MATERIAL AND METHODS

It was a descriptive, observational study conducted at Khyber Teaching Hospital, Peshawar including both wards and out-patient departments. We inspected 100 sphygmomanometers for physical defects and assessed their accuracy against a new, standard mercury manometer at four different pressure points. Sixty-two sphygmomanometers were collected from 15 different wards and

38 were collected from out-patient departments. The condition of each component of the sphygmomanometer was evaluated using the following criteria:

1. The bladder was considered defective if it was worn or torn or if it prolapsed out of the cuff.
2. The pump bulb was considered defective if it was cracked or excessively worn out and/or if it leaked air when being pumped and/if there was dirt in the inlet valve.
3. The rubber tubing was considered defective if there were holes or leaks and /or if it had cracks, and /or the length of tubing was too short.
4. The control valve was considered defective if there was wear or air leakage in the valve or dirt in filter, and/or if it was difficult to open or close the valve.
5. The face plate was considered defective if it was cracked or broken, and/or if there was some trouble in legibility or pressure due to dirt on inside of glass tube or face plate or due to oxidation of mercury.
6. The gauge was considered defective if the indicator needle did not point to the "zero" when there was no pressure in the manometer.

A component was classified as satisfactory when it was in perfect working order and unsatisfactory when it was defective according to the above criteria.

Electronic devices used for blood pressure measurement were excluded from the study.

The cuff was wrapped around a large bottle for functional assessment. It was tested whether

the procedures of inflating the bladder, and halting and restarting at any desired pressure were easily performed. Also, it was examined whether the rate of fall of mercury or indicator needle could be easily controlled to 2 mmHg per second and whether there was any loss of pressure greater than 1 mmHg per second while the control valve was closed at 250 mmHg of pressure.

All the sphygmomanometers tested were compared with a new, standard mercury sphygmomanometer at four pressure levels (240, 180, 120, and 60) and the readings were recorded.

RESULTS

All the sphygmomanometer in the various units and out patient departments were mercury sphygmomanometers.

The results of the physical condition of the components of sphygmomanometers are shown in Table 1. The most physical defects were: defective pump bulb (60%), defective rubber tubing (38%), and mercury level not pointing to the zero (37%).

The cuffs of 93 sphygmomanometers were of adult size and contained bladders of lengths ranging from 20 to 28 cm and widths ranging from 10 to 14 cm. Seven sphygmomanometers in pediatric in-patient and out-patient clinics in the hospital had smaller cuff size containing bladders of lengths ranging from 15 to 18 cm and widths ranging from 6.5 to 7.5 cm. Twenty of the 62 (32%) ward cuffs and 13 (34%) OPD cuffs had bladder lengths less than 24 cm recommended for use on normal adults. In addition, 24 (39%) ward cuffs and 16 (42%) OPD cuffs had bladder widths less than the 13 cm recommended for use on normal adults. For the purpose of this study, a test manometer was defined as being intolerant if it deviated from the new, standard manometer by greater than ±3 mmHg at two or more of the test pressure levels.

Table 1: Physical condition of the components of sphygmomanometer.

Component	OPDs		Wards	
	Satisfactory	Unsatisfactory	Satisfactory	Unsatisfactory
Inflation Bulb	10	28	30	32
Control Valve	24	14	40	22
Rubber Tubing	20	18	42	20
Cuff	25	13	43	19
Bladder	26	12	50	12
Indicator Needle	24	14	39	23
Face Plate	20	18	44	18

Table 2: Functional status of Sphygmomanometers.

Function	OPDs		Wards	
	Satisfactory	Unsatisfactory	Satisfactory	Unsatisfactory
Inflation	22	16	52	10
Delation	26	12	54	8
Leakage	24	14	52	10
Gauge accuracy	26	12	28	34

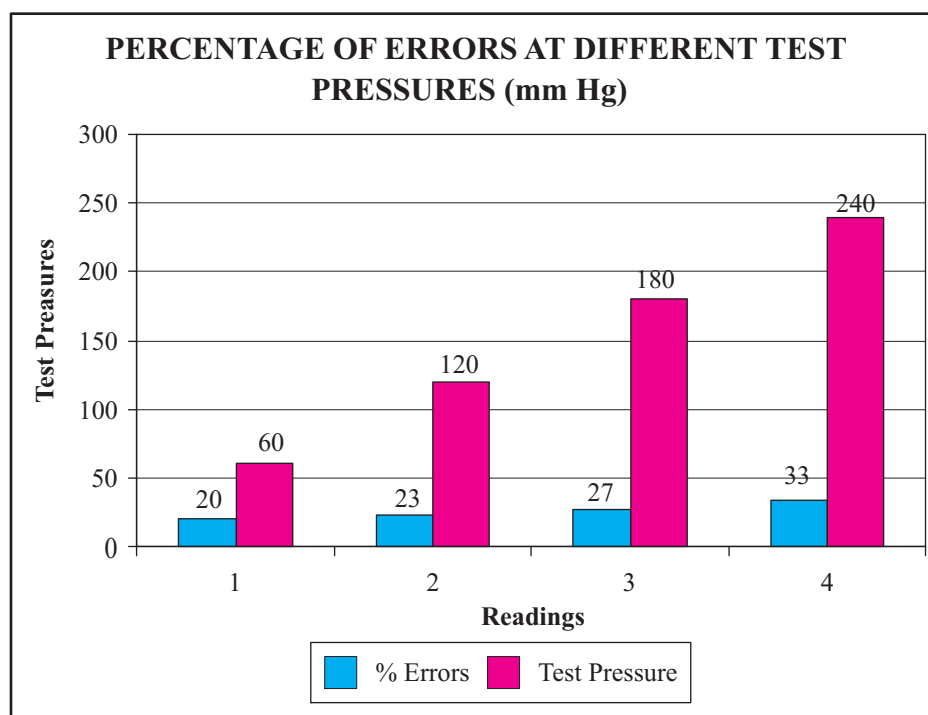


Figure: Showing percentage of errors at different test pressures.

Thirty-four (55%) of the 62 ward sphygmomanometers and 12 (32%) of the 38 OPD sphygmomanometers were intolerant.

In total, 46 (46%) of the 100 test sphygmomanometers were intolerant. There were faults in the inflation-deflation system of 46 (46%) sphygmomanometers. There was leakage in system of 34 (34%) sphygmomanometers. The functional status of the test sphygmomanometers is shown in Table 2.

The percentage of errors at each of the four test pressures (240, 180, 120, and 60) are shown in Figure.

DISCUSSION

Even when purified from all errors, indirect BP measurements do not completely reflect the

intra arterial pressure. It is, therefore, highly important to avoid all preventable errors caused by an improper technique of BP measurement and inaccurate sphygmomanometers. One of the most significant findings in our study was that nearly all sphygmomanometers used in Khyber Teaching Hospital, Peshawar, were mercury sphygmomanometers. Joint National Committee (JNC) VII guidelines also recommend the use of mercury sphygmomanometer and if aneroid models are used, they should be checked at an interval of 6-12 months.^{8, 9, 14-17} Rationality of this recommendation is that frequent use causes the metal bellows of the aneroid gauges to lose their elasticity, especially in higher pressures. In addition, any trauma to the instrument may disrupt the gear system, thus increasing a tendency to faulty measurement throughout the entire scale.¹⁰

Our results reveal some suspicion about the accuracy of sphygmomanometer used in our country. Cady et al also mentioned that 28% of the sphygmomanometers used in emergency departments were inadequately calibrated.¹⁹

In our study 46% of the sphygmomanometers showed pressure deviation exceeding the recommended tolerance of error at 2 or more test pressure levels. This is greater than the intolerance rates reported in some studies in the literature.¹⁰⁻¹³ We found greater magnitudes of error at the highest level (240 mmHg). We observed differences exceeding 3 mmHg in 20% of devices at 60 mmHg, 23% at 120 mmHg, 27% at 180 mmHg and 33% at 240 mmHg. (Fig. 1) Other studies also showed that the errors occur distinctly at the different levels of evaluation. Fisher observed differences exceeding 3 mmHg in 22% of the devices at 60 mmHg, in 25% at 120 mmHg, in 29% at 180 mmHg, and in 34% at 240 mmHg.¹⁸ Intolerant sphygmomanometers have a tendency to underestimate the patient's actual BP. The most common physical defect leading to inaccuracy of manometer appears to be defective pump bulb (60%) followed by defective rubber tubing (38%) and mercury level not pointing to "zero" (37%).

Any difficulty of inflating the bladder due to any wear, cracking, holes, tears of these components or dirt in filter can cause venous distension of the forearm and a concomitant low flow, thereby producing the auscultatory gap. In addition, difficulty in control the release of pressure leads to underestimation of systolic and overestimation of diastolic blood pressures. Reparable nature of the defects of the inflation-deflation system shows the importance of the regular maintenance. Our study determined that the dimensions of some of the bladders in both wards and OPDs sphygmomanometers do not meet the recommendations of the American Heart Association (AHA) and British Hypertension Society (BHS).^{16,17} According to the AHA and BHS, a normal adult-sized bladder should have at least dimensions of 13x24 cm and 12x26 cm respectively. Use of bladder of inadequate dimensions leads to overestimation of BP. This increases the possibility of misdiagnosing normotensive patients as hypertensive.

CONCLUSION

The functional and physical conditions of sphygmomanometers used in our set up are insufficient and defective. Sphygmomanometers in use should be regularly assessed.

REFERENCES

1. Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. The sixth report of the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure. *Arc Intern Med* 1997; 157: 2413-46.
2. Aviv A. Hypothesis: pulse pressure and human longevity. *Hypertension* 2001; 37: 1060.
3. National Institute of Health, National Heart, Lung, and Blood Institute. The Sixth Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood pressure, 1997; 153: 154-83.
4. Zanchetti A, Chalmers JP, Arakawa K, et al. The 1993 Guidelines for the management of mild hypertension: memorandum from WHO/ISH meeting. *Hypertension* 1993; 22: 392-403.
5. Perloff D, Grim C, Flack J, et al. Human blood pressure determination by sphygmomanometry. *Circulation* 1993; 88: 2460-70.
6. Frohlich E, Grim C, Labarthe DR, et al. Recommendations for human blood pressure determination by sphygmomanometers. *Circulation* 1988; 77: 501A-514.
7. Campbell NRC, Chockalingam A, Fodor JG, McKay DW. Accurate, reproducible measurement of blood pressure. *Can Med Assoc J* 1990; 143: 19-24.
8. The Fifth Report of the Joint National Committee on Detection, Evaluation and Treatment of High Blood Pressure. *Arch Intern Med* 1993; 153: 154-83.
9. Frohlick ED, Grim C, Labarthe DR, et al. Recommendations for human blood pressure determination by sphygmomanometers. Report of a Special Task Force Appointed by the Steering Committee, American Heart Association. *Hypertension* 1988; 11: 210a-21a.
10. Baily RH, Knaus VL, Bauer JH. Aneroid sphygmomanometers, an assessment of accuracy at a university hospital and clinics. *Arch Intern Med* 1991; 151: 1409-12.
11. Burke MJ, Towers HM, O'Malley K, Fitzgerald DJ, O'Brien ET. Sphygmomanometers in hospital and family practice: problems and recommendations. *BMJ* 1982; 285: 469-71.
12. Conceicao S, Ward MK, Kerr DNS. Defects in sphygmomanometers: an important source of error in blood pressure recording. *BMJ* 1976; 1: 886-8.
13. Perloff D, Grim C, Flack J, et al. Human blood pressure determination by sphygmomanometry. *Circulation* 1993; 88: 2460-70.

14. American Society of Hypertension. Recommendations for routine blood pressure measurement by indirect cuff sphygmomanometry. *Am J Hypertension* 1992; 5: 207-9.
15. Petrie JC, O'Brien ET, Littler WA, de Swiet M. Recommendations on blood pressure measurement, British Hypertension Society. *BMJ* 1986; 293: 611-5.
16. Kyrkendall WM, Feinleib M, Freis ED, Mark AL. Recommendations for Human Blood Pressure Determination by Sphygmomanometers. *Circulation* 1980; 62: 1145A-55A.
17. O'Brien ET, Petrie JC, Littler WA et al. Blood Pressure Measurement. Recommendations of the British Hypertension Society. 3rd ed, BMJ Publishing Group, Great Britain, 1997.
18. Fisher HW. The aneroid sphygmomanometer: an assessment of accuracy. *Med Cardiovasc* 1978; 3: 769-71.
19. Cady CE, Pirrallo RG, Grim CE. Ambulance sphygmomanometers are frequently inaccurate. *Am J Hypertension* 1996; 9: 107A.
20. Waugh, Jason J.S, Gupta M, Rushbrook J, Halligan A, et al. Hidden errors of aneroid sphygmomanometers. *Blood Pressure Monitoring* 2002; 7: 309-12.

Address for Correspondence:

Dr. Jamal Ud Din
Assistant Prof. Medical A Unit
Khyber Teaching Hospital
Peshawar, Pakistan
E-mail: jamal_marwat1@yahoo.com