

# The Accuracy of Blood Pressure Device

Najla Ayoub<sup>1</sup>, MRCP, Hana Alsaed<sup>2</sup>, BSc, Lamy Ayoub<sup>3</sup> MSc

<sup>1</sup>Department of Pediatric, College of Medicine, Al Mustansiriya University, Baghdad, Iraq.

<sup>2, 3</sup> Central organization for standardization and quality control.

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## Address for Correspondence:

Dr. Najla Ayoub

E-mail: Najla.ayoub@yahoo.com

## Abstract

**Background:** One of the factors affecting the accuracy of readings of blood pressure is the equipment used. Defects or inaccuracy of the sphygmomanometer may be source of error in blood pressure measurement.

**Aims:** This study had two objectives. Firstly, to assess the accuracy of sphygmomanometer used in general practice and secondly to assess the physical condition.

**Materials and Methods:** A total of 50 mercury and aneroid sphygmomanometers were tested for accuracy and physical condition.

**Results:** The results were that of the mercury and aneroid sphygmomanometers tested, 30% were inaccurate, of these, 10% recorded an error greater than 10 mmHg. Both types of sphygmomanometers were evaluated for conditions of cuff/bladder, pump bulb, and valve. Air leaks / holes in the pump bulb was found in 4% and bladder damage in 6% and indicator needles not pointing to the zero.

**Conclusions:** It is necessary that all equipment used for blood pressure measurement should be checked for accuracy on regular period.

**Keywords:** Accuracy, Calibration, Blood Pressure, Measurement

## INTRODUCTION

In clinical practice, the diagnosis of hypertension is performed by indirect measurement of blood pressure using mercury or an aneroid sphygmomanometer. Therefore the accuracy of the values obtained is essential, since errors may deprive hypertensive patients of the benefits of hypertension treatment and expose normotensive patients to unnecessary treatment.<sup>[1-4]</sup> Although several factors are important for accurate blood pressure measurement, the most important factor to obtain accurate values is to use adequately calibrated devices. Assurance of accurate calibration of the equipment whether mercury or aneroid should be checked at an interval of (6-12) months.<sup>[3, 5, 6]</sup> Problems related to the calibration of the manometers well as damage of the bladder, rubber bulbs, pump and valve of the system which allow the inflation and deflation of the

cuff can lead to errors in the readings obtained. The advantage of aneroid manometer is mercury-free, easily transportable, well understand by user, easy to check calibration, can be used on most patients. Disadvantage is manual devices, can be prone to observer bias.

Wear and in incorrect reading, requires regular calibration check. Mercury manometer is bigger and heavier than the aneroid and contains toxic substance.<sup>[7]</sup> In this study we evaluate the accuracy of both types of sphygmomanometers and their physical conditions.

## MATERIALS AND METHODS

We tested the accuracy and physical condition of 50 sphygmomanometers 40 from various private medical practices and 10 from different general hospitals.

### Visual assessment

The condition of each component of the sphygmomanometer was evaluated using the following criteria.<sup>[5, 8, 9, 10]</sup>

- 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, and 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 if excessive wear and cracking were present and length was too short.
- 4- The control valve was considered defective if there was wear or air leakage in the valve or dirt in the filter, 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 if there was some trouble in legibility of pressure due to dirt on inside of glass tube or face plate or due to oxidization 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.
- 7- Bouncing of the column of the mercury during inflation and deflation.
- 8- The filter at the top of the column of mercury was Permeable.

### Accuracy assessment

To assess the accuracy of sphygmomanometers, the device to be tested was compared with the standard mercury manometer at ten pressure level, according to the following procedure:

- 1- Connected the device to the mercury manometer.
- 2- Pressure the system until it exceeds 250 mmHg.
- 3- Slowly open the valve in order to reduce pressure.
- 4- Record the values between the two manometers over an average of ten readings.
- 5- The difference in readings over several set points is calculated.
- 6- Sphygmomanometers is considered calibrated when the error was  $\leq 3$  mmHg, what corresponds to 1% of the total scale and is considered inaccurate if there were an error of 4 mmHg or more at test point.<sup>[8]</sup>

## RESULTS

A total of 50 sphygmomanometers were tested. Of these, 45 (90%) were mercury and 5 (10%) aneroid. The results of sphygmomanometers accuracy are shown in [Table 1].

**Table 1.** Results of sphygmomanometer accuracy checks.

Sphygmomanometers		
No.	Percentage	Error (mmHg)
10	20%	$\geq 5$
5	10%	$\geq 10$
35	70%	$\leq 3$

Both mercury and aneroid sphygmomanometers showed errors in 30%. Ten of mercury sphygmomanometers recorded an error greater than 5 mmHg, while 10% of both types recorded an error greater than 10 mmHg. The second evaluated was physical condition of the equipment. The bulb pump, rubber bladder and valve. The most defects were air leaks/holes in the bulbs (4%), bladder damage (6%), dirt in mercury. Most of the sphygmomanometers have one problem either to calibration or the physical condition of cuff, rubber bladder, bulb pump and valve that interfere with blood pressure measurement accuracy.

## DISCUSSION

Although blood pressure measurement is several factors that may contribute to measurement error. The American Heart Association addresses factors that can affect blood pressure measurement, factors related to (a) the observer, (b) the technique, (c) the environment, (d) the patient, and (e) the equipment.<sup>[3]</sup> Both aneroid and mercury sphygmomanometer can be potential source of error, although both give precise and good result when accurately calibrated and in good physical condition. Calibration errors in both aneroid and mercury device can be caused by improper usage, dropping of the devices during blood pressure measurement, lack of appropriate storage condition and facilities, and aging or wear of equipment. In the present study it was found that the degree of inaccurate of mercury manometer was lower than in aneroid manometer. The frequent use causes the metal bellows of aneroid gauges to lose their elasticity, especially in higher pressure. In addition, any trauma to the instrument may disrupt the gear system, thus increasing a tendency to faulty measurements

throughout the entire scale.<sup>[8]</sup> Results of this study are compared with other published research. In a study by (Waugh et al. 2002)<sup>[11]</sup> found that 22% of readings from mercury sphygmomanometer with magnitude of error  $\geq 4$  mmHg, 42% of aneroid readings were  $\geq 4$  mmHg and 19% of the aneroid device had errors greater than  $> 5$  mmHg. (Mion and Pierin 1998)<sup>[8]</sup> Found that 58% of aneroid and 21% of mercury manometers to be failed the calibration test. (Ashworth et al. 2001)<sup>[12]</sup> Found that 2% of the mercury and 15% of aneroid device were to be inaccurate. (Ali and Rouse 2002)<sup>[13]</sup> Found that 10% of aneroid and 1% of mercury device display errors  $> 10$  mmHg. Our results demonstrated that 30% of mercury and aneroid device are inaccurate. 10% showed an error greater than 10 mmHg. These inaccuracies could clearly lead to errors in blood pressure measurements and have major consequences for the appropriate treatment of the patient. In physical Condition of the rubber bladder of the cuff, bulb, pump, and valve may also interfere with sphygmomanometer reliability. (Conceicao et al.)<sup>[14]</sup> Found that half the sphygmomanometers had faults in the control valves. Leaks in the controls valves make inflation of the rubber cuff difficult and the speed of the deflation difficult to control. This can cause erroneous readings with underestimation of the systolic pressure and overestimation of the diastolic pressure. Aging of the bulbs and rubber cuff was especially evident throughout this study's assessment of the manometers.

Leaking caused holes in the connections or aging of the rubber bladder or the bulbs were also found and can cause inaccuracy in blood pressure measurements.

## Conclusion

The present study showed inaccurate in both mercury and aneroid sphygmomanometer in both private and hospital medical practice. Thus, numerous possibilities for error due to the lack of maintenance of the equipment that point to the lack of importance of a period evaluation. We recommend that mercury and aneroid sphygmomanometer must be checked regularly in order to avoid errors in the blood pressure measurement and consequently the diagnosis and treatment of hypertension.<sup>[6, 15]</sup>

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