Letter to the Editor

Knowledge, Attitude, Behavior, and Practice of Interns Toward Errors in Sphygmomanometer and Blood Pressure Measurement

To the Editor:

Sphygmomanometers are vital pieces of medical equipment. The accuracy of 150 sphygmomanometers in clinical use were checked independently by experts, and knowledge and practice regarding appropriate use of these instruments were assessed by questionnaires given to 300 medical interns at 4 separate medical colleges in India. There were deficiencies found in 63 of the 150 devices. Among the 287 interns completing the questionnaire, only about half indicated an awareness of how to check the sphygmomanometers for obvious malfunctions, and, similarly, there was a suboptimal awareness of correct methods for measuring blood pressure (BP). Concerted efforts should be directed at improving the performance of this important clinical technique among young practitioners.

BACKGROUND

Hypertension (HTN) has become a major public health problem in both developing and developed countries.[1,2] The appropriate treatment of HTN requires an accurate diagnosis, which can be made by measuring BP.[3] Defective diagnosis and treatment of HTN has been proved to cause serious cardiovascular and cerebrovascular complications.[4] Thus, proper BP measurement is crucial for both documenting the presence and degree of HTN and for assessing BP control while the patient is on regular treatment.

In countries with limited resources, the diagnosis of HTN is made by using mercury sphygmomanometer in clinical practice. Many technical errors might occur related to the equipment used in practice, and this could influence BP reading. Defective status of hospital sphygmomanometers in use were shown earlier.[5,6] Inaccurate and unreliable equipment can lead to erroneous diagnosis, with serious consequences for the patient.[7] The American Heart Association (AHA)[8] recognizes 3 sources of error in the measurement of BP: observer bias, faulty equipment, and failure to standardize the techniques of measurement.

International studies confirm that teaching, training, and knowledge toward BP measurement and apparatus for health care professionals are suboptimal.[9–11] Also, these gaps in training are continuing in medical education and among interns and practitioners.[10,12] Hence, this present study was undertaken to find out the errors in sphygmomanometer and intern's knowledge to notify it and also to evaluate their knowledge, attitude, behavior, and practice (KABP) of BP measurement and diagnosis of HTN.

MATERIAL AND METHODS

The accuracy and conditions of 150 sphygmomanometers in use in 4 different teaching hospitals in India were evaluated by two engineers (GD and RS) who were trained to assess the biomedical equipment. For data collection, we assessed the accuracy of calibration by using zero error, glass tube, lid, mercury column in tube, scale, regulator for mercury flow, rubber tube attached with mercury box, tube connecting cuff and bulb, bladder, cloth covering cuff, bulb, and metal box.

We distributed an anonymous structured pretested questionnaire among 300 interns of 4 different medical colleges in India. The questionnaire was focused towards looking for errors in sphygmomanometer and KABP of BP measurement technique. All interns were briefed about the proposed work and asked to answer individually. The details were analyzed by simple descriptive statistics.

RESULTS

All 150 sphygmomanometers were of mercury type. The cuffs of 112 were of adult size and contained bladders of length ranging from 19 cm to 26 cm and width ranging from 10 cm to 13 cm. The remaining 38 were of pediatric size, with bladder length and width from 15 cm to 18 cm and 6.5 cm to 7.5 cm, respectively. The errors noticed among mercury sphygmomanometers, which were evaluated by 2 engineers, are reported in Table I.

On average, 75 interns from each of the 4 medical schools were given the questionnaire, and a total of 287 (96%) responded. Among them, 167 (58%) were men and 120 (42%) were women,

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with a mean age of 23.5 in the former and 23 in the latter. All had clinical training at inpatient and outpatient clinics for at least 3.5 years, with completion of at least 6 months of internship in clinical postings and were trained to measure and report BP to attending clinicians. The interns' knowledge to look for errors in sphygmomanometer and KABP toward BP measurement techniques are reported in Table I and Table II, respectively.

DISCUSSION

Mercury sphygmomanometer is endorsed by the AHA to measure BP indirectly. When working properly, it gives accurate and reliable results.[13] The most important findings of this study were the demonstration of the degree of inaccuracy and imperfect physical conditions of the hospital sphygmomanometers in use. Less than 15% of equipment was in a proper condition for use. Mion and colleagues[7] reported that one third of the sphygmomanometers had problems in calibration and other technical errors.

In this study, zero error was noted in 56 (37%) sphygmomanometers, which might have occurred due to improper handling, lack of adequate care during use, transportation, aging, and inappropriate storage of equipment.[7] The mercury should be leveled to "zero" prior to use in order to measure accurate BP.[14] The most important sources of error in instruments, leading to functional insufficiency, were flawed control valve (28%), suboptimal status of cuff (34%), defect in rubber tubing (6%) and bulb (8%), with air leakage at bulb (26%), connector (13%), and screw (7%). Improper conditions of bladder, bulb, pump, and valve may also interfere with sphygmomanometer reliability in measuring BP.[7]

In only 14% of sphygmomanometers, mercury column raised freely up to 300 mm Hg when the air was inflated into the bladder and mercury column came down immediately on deflating the bladder. In addition, the parts/function of 14% of apparatuses were perfectly normal, as they was recently purchased. The remaining 86% had problems with inflation-deflation. The difficulty in inflation and deflation were due to wear/tear in the bladder or a dirty filter, which can cause venous distension of forearm and a concomitant low flow, thereby producing the auscultatory gap.[6,7] In addition, difficulty in the control of release of pressure leads to misinterpretation of systolic and diastolic pressures.[6,7]

We observed a broken glass column in 6% and spoiled mercury (blackish ash/ash color) and air bubbles in the mercury column in 9% of instruments. Mercury-column sphygmomanometers are considered the gold standard of accuracy in the measurement of BP, provided the glass column is clean, the mercury is not contaminated/oxidized, the air vent is not clogged, and there is an appropriate amount of mercury in the column.[3,7] In our hospitals, most bladders do not meet the dimensions of adult-sized bladder of at least 13×24 cm and 12×26 cm,[7] which is currently recommended by the AHA and British Hypertension Society (BHS). This increases the possibility of misdiagnosing normotensive patients as hypertensive.[7]

It is always expected that health care professionals use BP devices correctly to achieve a reliable measurement. Unfortunately, considerable concern has arisen about the inaccuracy of BP measurement and the possible sources of errors and haphazard documentation.[15,16] In our study, we demonstrated inconsistencies and lack of knowledge among interns toward BP apparatus and measurement. The knowledge to look for zero error and leakage of air and air bubbles in the mercury column was satisfactory among 77 (27%), 140 (49%), and 207 (72%) interns, respectively. Although most interns (70%) did not notify/identify the errors in the equipment,[17] some identified the errors and suggested them for service. Improper selection of cuff size leads to overestimation of BP, if the bladder cuff is too small/large or if the examinee is thin/obese.[18,19]

Even though phase 5 Korotkoff sound was recommended for diastolic BP,[20] only 15% of interns considered it. This mishap of recording diastolic BP, a predictor of stroke mortality,[21] was noticed among German and British clinicians,[22,23] as well as systolic BP, a sensitive indicator of cardiovascular disease.[24] Error was also induced by rounding off,[12] as 5% of interns rounded off close to 5 mm Hg or more in the present study. Although interns from various medical schools were evaluated, we could not find any significant difference in their overall assessment. All stated that they had not received any course/training on these aspects.

CONCLUSIONS

Sphygmomanometers that receive heavy use in the field can lose the linearity of their calibration and reliability in BP measurement.[25] Also, standards and recommendations for the use and maintenance of sphygmomanometers should be constituted and clinicians and hospital staffs should be trained to evaluate the apparatus and motivated to assess their equipment periodically.[26] A formal audit in the use of sphygmomanometers in hospitals may encourage

Table I. Common Errors in Sphygmomanometer and What Interns Looked For			
	Errors/Function, (n=150), No. (%)		What Interns Looked for (n=287), No. (%)
Parts of Sphygmomanometer	Yes	No	
Lid			
Is the glass tube broken?	9 (6)	141 (94)	244 (85)
Is there any mercury leakage from the glass tube/top/bottom of tube?	0 (0)	150 (100)	103 (36)
Scale			
Is the painting peeled or unclean?	134 (89)	16 (11)	114 (40)
Are the markings on the glass tube clear?	92 (61)	58 (39)	235 (82)
Is there any zero error in the scale?	56 (37)	94 (63)	77 (27)
Regulator for mercury flow			
Is there any regulator for mercury flow into glass tube?	113 (75)	37 (25)	66 (23)
Is the regulator or lock handle in working condition?	79 (53)	71 (47)	81 (28)
Rubber tube attached with mercury box fixed in the lid			
Is the rubber tube connected with bladder cuff directly?	120 (80)	30 (20)	77 (27)
Is there any air leakage in the connector?	19 (13)	131 (87)	33 (11)
Is there any leakage in the tube connected to the bladder?	0 (0)	150 (100)	91 (32)
Tube connecting bladder cuff and bulb			
Is the tube smooth and uniform?	99 (66)	51 (34)	119 (41)
Have rug or plaster?	119 (79)	31 (21)	191 (67)
Bladder			
Is it inflatable?	117 (78)	33 (22)	278 (97)
Does it contain plaster?	20 (13)	130 (87)	278 (97)
Cloth covering the bladder cuff			
Is the cloth clean (cloth with Velcro/hook/tail end)?	21 (14)	129 (86)	163 (57)
Is the Velcro/hook working well?	133 (89)	17 (11)	196 (68)
Bulb			
Is the bulb intact?	138 (92)	12 (8)	241 (84)
Is there air leak through bulb?	39 (26)	111 (74)	140 (49)
Is the entry valve of the bulb missing?	16 (11)	134 (89)	14 (5)
Is the entry valve of the bulb defective?	42 (28)	108 (72)	11 (4)
Regulator screw near the bulb			
Is the screw very easy to open?	52 (35)	98 (65)	9 (3)
Is there any air leakage through the screw?	10 (7)	140 (93)	7 (2)
Metal box			
Is the lock in the metal box working?	61 (41)	89 (59)	11 (4)
Is there a separate place to keep the bulb safe in the box?	72 (48)	78 (52)	95 (33)
Is the screw connecting the lid and box intact?	79 (53)	71 (47)	23 (8)
Mercury			
On inflating the bladder, does the mercury raise up to 300 mm freely?	21 (14)	129 (86)	281 (98)
Does the mercury in the tube stand without coming down after inflating the bladder while locked tightly near bulb?	21 (14)	129 (86)	146 (51)
What is the color of mercury?			
1 – Silver	137 (91)	–	0 (0)
2 – Blackish ash	7 (5)	–	0 (0)
3 – Ash	6 (4)	–	0 (0)
Is the mercury column with air bubbles?	14 (9)	136 (91)	207 (72)

and improve the accuracy and uniformity in BP recording.[27]

Also, we concluded that KABP among interns were suboptimal, which has been consistently proven by other studies conducted among health care professionals from both developed and developing nations.[11,12,15,22,23] This is due to lack of training in these aspects[10] during medical education. This can seriously affect the diagnosis and clinical management of silent, common, and serious diseases. Also, it could have financial implications and affect health statistics. Hence, health care professionals

Table II. Knowledge, Attitude, Behavior, and Practice of Interns Toward Blood Pressure (BP) Measurement Technique

Variables	Interns (n=287), No. (%)
BP apparatus	
Requested BP apparatus for service	78 (27)
Training/class, attended for	0 (0)
BP apparatus maintenance/service/usage	
Identification of faulty equipment	86 (30)
Regular check of BP apparatus	40 (14)
Preferred arm for BP measurement	
Right	184 (64)
Left	60 (21)
Both	43 (15)
Preferred position for BP measurement	
Lying	181 (63)
Sitting	72 (25)
Standing	0 (0)
Lying and standing	34 (12)
Arm position while measuring BP	
Arm fully supported	135 (47)
Arm with cuff at heart level	155 (54)
Inflation pressure	
Estimated every time	261 (91)
Reinflates 30 mm Hg after disappearance of radial pulse	256 (89)
Reinflates 20 mm Hg after disappearance of radial pulse	5 (2)
Systolic pressure	
First sound/first loud sound	287 (100)
At least 2 repetitive loud sounds	0 (0)
Diastolic pressure	
Phase 4 Korotkoff sounds	244 (85)
Phase 5 Korotkoff sounds	43 (15)
Rounding off BP measurement	
2 mm Hg	29 (10)
5 mm Hg	244 (85)
>5 mm Hg	14 (5)
Repeat BP measurement	267 (93)
Interpretation of auscultatory gap	75 (26)

should take the necessary steps to improve their knowledge in assessing and evaluating BP devices and techniques to measure BP. This could be done through training programs/continuing medical education, as shown earlier.[28] Medical schools should include programs on quality control of medical devices and diagnostic approaches toward BP.[10]—Ramachandran Meenakshisundaram, MD, rmsundar_chandran@yahoo.co.in;[1]
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