Oscillometric Finger Blood Pressure versus Brachial Auscultative Blood Pressure Recording

Yuruk Iyriboz, MD, MPH
Baton Rouge, Louisiana

In this study, a recently marketed proprietary finger blood pressure monitor, the Marshall, Astro F-88, was compared with the standard auscultative brachial mercury sphygmomanometer on 125 subjects. Measurements were undertaken according to the standards set by the American Heart Association. Sensitivity of the finger blood pressure measurement was 76% for systolic and 75% for diastolic blood pressure in diagnosis of high blood pressure (systolic > 140 mm Hg and diastolic > 90 mm Hg). Specificity was 86% for systolic and 82% for diastolic blood pressure. Positive predictive values were 58% for systolic and 38% for diastolic blood pressure in the study population in which prevalence of hypertension was 12%. The correlation coefficient (Pearson) for systolic values between devices was 0.76 (P < .0001) and 0.57 (P < .0001) for diastolic pressure. Values obtained by the finger monitor were found to be higher than those obtained by the mercury sphygmomanometer. Mean differences and standard deviations (paired t test) for systolic and diastolic pressures between the two devices were 2.3 ± 14.9 mm Hg (P < .08) and 2.9 ± 14.5 mm Hg (P < .02), respectively. These values are not in accordance with the proposed national standards because only 48% of the systolic and 37% of the diastolic blood pressure measurements were within 5 mm Hg of the mercury sphygmomanometer measurements. Therefore, although these differences may well be due to different techniques of monitoring employed by the devices, this device is not recommended for evaluation of blood pressure. **J Fam Pract 1990; 31:376-380.**

Improved technology has increased sales of self-measurement equipment for blood pressure.[1] Health professionals have demonstrated interest in self-monitoring of blood pressure, but are concerned about accuracy.[2–4]

Self-monitoring of blood pressure may have some problems intrinsic to the type of instrument being used.[5] Strong emphasis is therefore laid on recalibration of these instruments at least once a year.[6–8] An extensive study found that automated devices tend to attract patients who are already known to have high blood pressure and may actively deter some individuals from seeking further help.[9]

The Marshall Astro Finger-88 blood pressure monitor (Marshall Division of Marshall Products, Inc, 600 Barclay Blvd, Lincolnshire, Ill) measures blood pressure from arterial oscillations located at the left index finger. It is a compact instrument that is easy to use. No studies assessing this instrument have been published; however, this study was carried out to demonstrate the accuracy and any inherent bias of the F-88 by comparing it with a standard wall-mounted mercury sphygmomanometer.

METHODS

Subjects

Seventy-four women and 51 men participated in the study. Sixty-seven were black and 58 white. Average age for women was 44 years and for men 43 years. All subjects were recruited from an ambulatory primary care setting. None of the subjects presented with a complaint of high blood pressure or related symptomatology and were not taking antihypertensive medication. Sixty subjects had upper respiratory tract infections, 45 had skin infections, 12 had contact dermatitis, 1 had gonorrhea, 4

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From the Exercise Physiology Laboratory, Department of Kinesiology, Louisiana State University, Baton Rouge. Requests for reprints should be addressed to Yuruk Iyriboz, MD, Exercise Physiology Laboratory, Department of Kinesiology, Louisiana State University, Baton Rouge, LA 70803.

came in for a pregnancy test, and 13 for a pre-employment physical. Average blood pressure for all subjects (mean plus or minus standard error of the mean [SEM]) was 121.7 ± 7.7 for systolic and 73.0 ± 1.1 for diastolic pressures. There were 5 subjects who had isolated systolic high blood pressures varying between 190 and 150 mm Hg and 10 with high blood pressures varying between 170/116 and 150/96 mm Hg. Distribution of the subjects according to age groups and average blood pressure (mean plus or minus SEM) were as follows: age 0 to 14 years, 8 (6.4%, 103.0 ± 4.3/63.8 ± 2.6 mm Hg); age 15 to 24 years, 18 (14.4%, 117.4 ± 4.8/72.5 ± 4.2 mm Hg); age 25 to 44 years, 40 (32%, 116.8 ± 2.4/72.0 ± 1.8 mm Hg); age 45 to 64 years, 36 (28.8%, 130.8 ± 3.3/77.8 ± 2.0 mm Hg); those aged above 64 years, 23 (18.4%, 127.1 ± 3.2/71.0 ± 2.8 mm Hg). The mean blood pressures did not differ between sexes and races within these age groups. The distribution of subjects is in accordance with the recommendations of the American Association for Advancement of Medical Instrumentation for evaluation of blood pressure measurement devices.[10]

Instruments

The Marshall Astro Finger-88 (F-88) consists of a small bladder 3-cm wide that completely encircles (diameter 2.5 cm; circumference 7.8 cm) the first phalanx of the left index finger. It completely blocks off the circulation by applying pressure on the arteries of the index finger. Tiny photoelectric elements detect the oscillations of pressure. When the pressure in the automatically inflated cuff exceeds the user's arterial pressure, the blood flow is blocked, and no arterial vibrations are detected. The amplitude of arterial oscillations increases when the the pressure in the cuff reaches user's systolic blood pressure. Automatic cuff deflation then reduces pressure, and the reading at which oscillations suddenly decrease is interpreted as the user's diastolic pressure. Blood pressures are displayed to the nearest millimeter. All the readings are displayed on a digital screen (liquid crystal) until the instrument is turned off. This feature enables recording of values after measurement. The instrument weighs 8 oz and its dimensions are 1.5 in. × 2.5 in. × 5.5 in.

The Baumanometer (WA Baum Co, Copiaque, NY) is a standard wall-mounted mercury sphygmomanometer. Appropriate-sized Velcro cuffs have been used during all measurements. The length of the bladder is always 80% or more than the circumference of the arm. The width is always more than 40% of this circumference, and the cuff covers a minimum of two thirds of the arm length. All of the mercury wall-mounted sphygmomanometers used in the study (one in each examination room) were compared with a new desktop mercury sphygmomanometer (Baumanometer) by employing a Y connector before the study. They were tested by rapid inflation and attaining a pressure of 200 mm Hg in 5 seconds. Four readings (at 200, 150, 100 and 50 mm Hg levels) were then taken from both instruments on a falling pressure at about 2 mm/sec. The wall-mounted sphygmomanometers that did not comply with any of the readings by the desktop sphygmomanometer were not used in the study.

Blood pressures were measured as follows: after increasing the pressure to 170 mm Hg (minimum), the pressure was reduced at about 2 mm/sec. The point at which repetitive clear tapping sounds first appear for at least two consecutive beats was considered the systolic blood pressure. If the repetitive clear tapping sounds were heard immediately before starting to deflate the cuff, pressure was increased to 30 mm Hg above the pressure displayed at that time. The point where repetitive sounds finally disappear (Korotkoff phase 5) was considered the diastolic blood pressure for adults. Korotkoff phase 4, muffling of sounds, was considered the diastolic pressure for subjects younger than 12 years of age (only seven subjects). All measurements were taken to the nearest 2 mm Hg.[11–14]

Procedures

Each subject was seen individually in a quiet, temperature-controlled (73°F to 75°F) examination room followed by waiting in the relaxed atmosphere of the waiting room for a minimum of 5 minutes. After a brief history was taken (which usually exceeded 5 minutes and during which time the patient was comfortably seated and legs not crossed), all the vital signs except blood pressure were taken. After the vital signs were recorded, blood pressure of each subject was first measured with the finger monitor and then with the wall-mounted mercury sphygmomanometer using the same (left) arm by the same physician. Each time, before using the mercury sphygmomanometer, the position of the meniscus was ascertained. The left arm at each measurement was kept horizontal and supported at the level of midsternum. The bottom edge of the cuff was always placed at least 1 inch above the antecubital fossa.[5,13–17]

Each subject was given a study number 1 through 125. Subjects were informed about automatic inflation and deflation aspects of the new finger monitor as well as a startle effect that could elevate their blood pressure. Subjects were then allowed to use the finger monitor several times before the actual measurements were taken, and they were also instructed in reading the digital displays for blood pressures. Following the procedure of measurement undertaken by the observer, the subjects were asked to read the displays, write them on a piece of paper together with their study number, fold the paper, and put it in an envelope provided by the observer. The observer

did not read the finger monitor displays. The folded pieces of paper were not opened and read until all of the 125 observation were made. Measurements were recorded on a preprinted data sheet providing information on each subject pertaining to age, sex, race, and blood pressure by both devices.

Data on systolic and diastolic blood pressures from both instruments were submitted to the following statistical procedures: (1) mean differences and standard deviations between the two devices (paired *t* test), (2) correlation coefficients (Pearson), (3) frequency distribution of differences between devices for each systolic and diastolic blood pressure measurement, and (4) sensitivity, specificity, and predictive values of the F-88 in detecting high blood pressure (systolic > 140 mm Hg, diastolic > 90 mm Hg).

RESULTS

Values obtained from F-88 tended to be higher than those obtained from the mercury sphygmomanometer. Mean differences and standard deviations for systolic and diastolic blood pressures between the devices were 2.3 ± 14.9 mm Hg ($P < .08$) and 2.9 ± 14.5 mm Hg ($P < .02$), respectively. The mean differences were unchanged upon stratification by age and sex. Only 48% of the systolic and 37% of the diastolic blood pressure measurements obtained by the F-88 were within 5 mm Hg of the mercury sphygmomanometer measurements. More than one quarter of the systolic blood pressure measurements and one third of the diastolic blood pressure measurements varied by more than 10 mm Hg. The correlation coefficient for systolic blood pressure between devices was 0.76 ($P < .0001$) and for diastolic 0.57 ($P < .0001$).

DISCUSSION

Self-monitoring of blood pressure is becoming increasingly important for several reasons. First, blood pressure measured by a patient at home gives a better estimate of genuine pressure levels in everyday life, since some patients react to measurements by physicians with a pressor response.[18] Second, self-monitored blood pressure is generally in good agreement with simultaneous intraarterial recordings.[19] Third, home monitoring improves adherence to treatment of antihypertension.[5,7,15,20,21] Last and of equal importance is that automated blood pressure measurement enables self-monitoring of blood pressure, which in turn can facilitate extensive and effective screening for high blood pressure.[7,21] A recent study showed that average daily blood pressure, not office blood pressure, best predicts cardiac end-organ damage among hypertensive patients.[22]

Nevertheless, reports on accuracy of automated home blood pressure monitors are contradictory.[3,5,23–25] The variability between these devices and the standard mercury column sphygmomanometer is attributed to measurement of different circulatory phenomena by different recording techniques.[26] Oscillometry, the technique employed by the F-88, is claimed to be more accurate than the auscultative method, especially in clinical situations when blood flow is diminished.[27] There are no definitive studies comparing oscillometry with other techniques, however, such as ultrasonic and microphonic techniques.

This study demonstrated that the F-88 overestimates blood pressure when compared with the standard mercury sphygmomanometer. At this time it does not meet proposed standards for accepted performance.[10] Although the mean differences both for systolic and diastolic blood pressures are less than 5 mm Hg, the standard deviations of both are significantly higher than 8 mm Hg. These values are not in accordance with the proposed national standards, which suggest that mean differences be less than 5 mm Hg with standard deviations less than 8 mm Hg.[10,11] According to the American Association for Advancement of Medical Instrumentation requirements " . . . for systolic and diastolic pressures, treated separately, the mean difference of the paired measurements of the test system and the comparison system shall be ±5 mm Hg or less, with a standard deviation of 8 mm Hg or less."[10] Using the standard definitions of 140 mm Hg or less as normal for systolic blood pressure and 90 mm Hg or less as normal for diastolic blood pressure, sensitivity (ability to identify blood pressure above 140 mm Hg for systolic and above 90 mm Hg for diastolic) was 76% for systolic and 75% for diastolic blood pressure. In other words, about one quarter of those with high blood pressure are incorrectly identified as normotensive. Specificity (ability to correctly identify those who have normal blood pressure) was 86% and 82% for systolic and diastolic blood pressure, respectively. The remaining 14% and 18% are incorrectly identified (as hypertensive). Prevalence of high blood pressure in the study group was 12%. The predictive values for a positive test (hypertension) were low, only 58% for systolic and 38% for diastolic blood pressure.

The study findings suggest that using the F-88 routinely is not appropriate in settings where accurate blood pressure determinations are important. The instrument demonstrated minimal bias but significant imprecision, which can be very misleading in home monitoring of blood pressure. Comparison of oscillometric finger blood pressure with that of brachial auscultation, and the disparity observed between two techniques in this study, however, can be attributed to the following:

1. Different recording techniques at different sites[3,23,24,28–32]

2. Differences in precision (F-88 nearest 1 mm Hg, mercury sphygmomanometer nearest 2 mm Hg), bias for even-digit reading, terminal digit preference,[33–36] and startle effects[2]

3. Differences in deflation rate[37]

4. Phase of respiration not taken into account while measuring blood pressure with any of the devices[26,38,39]

5. Measurement of diastolic pressure at different Korotkoff phase by the F-88[40,41]

6. Bias of blood pressure variability within persons, since each subject was measured only once by each device[42,43]

In conclusion, the results of this study show that the F-88 finger monitor significantly overestimates blood pressure when compared with the standard mercury sphygmomanometer. Other automated devices may have similar problems inherent to their technique of measurement. Patients should be advised to confer with their physicians before they purchase blood pressure monitors. Automated devices should not be purchased unless the manufacturers provide sufficient validation of accuracy.[44]

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