Inaccuracy of London School of Hygiene sphygmomanometer

The London School of Hygiene (LSH) sphygmomanometer is a mercury in glass manometer incorporating special features to reduce observer bias and digit preference. Originally intended for use by epidemiologists, it has been used in therapeutic trials, to compare direct and indirect blood pressures,[1] and as a reference standard against which automatic devices are tested.[2] Though validated against the standard mercury sphygmomanometer,[3 4] it gave lower recordings than the standard sphygmomanometer when both were compared with intra-arterial recordings.[5] We carried out a study to assess the accuracy of the LSH sphygmomanometer.

Methods and results

Two LSH sphygmomanometers were compared statically with a standard mercury manometer throughout the pressure range 0-250 mm Hg by connecting both devices to a single cuff wrapped around a cylinder. The internal diameters of the reservoirs and glass tubes of the LSH sphygmomanometers were measured by a micrometer. The LSH sphygmomanometers underestimated pressure, the error increasing with pressure so that at 200 mm Hg they recorded 196 mm Hg. The error was consistent with failure to calibrate for the relative diameters of the reservoir (24 mm) and glass column (3·8 mm). The scale of a mercury manometer is calibrated to compensate for the fall of mercury in the reservoir when pressure is applied. The correction factor (h_1), added to the recorded rise of mercury in the glass tube, is calculated as $h_1 = h_2(d_2)^2/(d_1)^2$, where h_2 is the rise of mercury in the glass tube and d_1 and d_2 the diameters of the reservoir and glass tube respectively.

The LSH sphygmomanometer was compared with the Hawksley random-zero sphygmomanometer in 20 patients with a wide range of blood pressures. Two trained observers unaware of the possible error in the LSH sphygmomanometer recorded the pressures (diastolic phase V) at a deflation rate of 2 mm Hg per second. Both devices were connected to a single cuff through a Y connector. A two-channel stethoscope was used so that both observers auscultated the same sounds, and the observers were separated by a partition. Four paired recordings (LSH and Hawksley sphygmomanometers) were made in each patient. The LSH sphygmomanometer underestimated the Hawksley recordings (figure) by a mean of 7·1 mm Hg ($p < 0.001$) and 3·6 mm Hg ($p < 0.001$) for systolic and diastolic blood pressures respectively (Student's t test for paired data). There was a negative correlation between the diastolic, but not systolic, error and heart rate ($r = -0.27$, $p < 0.05$).

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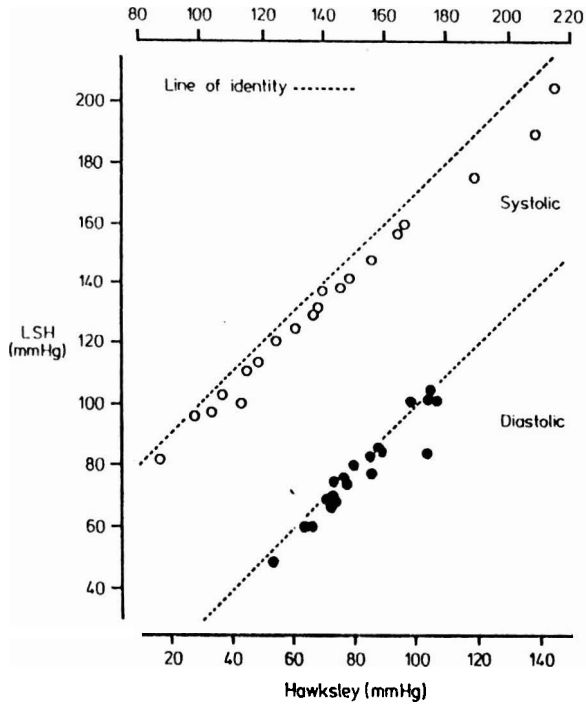

Comparison of mean recordings of blood pressure made in 20 patients with London School of Hygiene (LSH) and Hawksley random-zero sphygmomanometers.

Comment

The differences between the readings made with the LSH and Hawksley sphygmomanometers were greater than could be explained by the calibration error of the former alone. With a standard mercury manometer the observer watches a falling mercury column against a scale. If, as often happens, he is uncertain that he has heard the first sound he may delay a decision until he has confirmed the presence of sounds and then refer back to the point on the scale at which he thought sounds were first heard. Similarly, with the diastolic pressure the point of disappearance of sounds is referred to only after confirming that all the sounds have disappeared. In contrast, when the LSH sphygmomanometer is used the falling mercury column and pressure scale are not visible. Systolic pressure is indicated after the first sound when the observer is satisfied that sounds are being heard. Similarly, the diastolic pressure is indicated after the last sound, at the point where a sound is expected but fails to occur. There is therefore a tendency to underestimate blood pressure when using the LSH sphygmomanometer, and the error would be expected to increase at slower heart rates. This interpretation is supported by the finding of a negative correlation between the diastolic error and heart rate.

Our findings show that because of a calibration error and an interpretive tendency to underestimate systolic and diastolic pressures

the LSH sphygmomanometer is not suitable for studies of blood pressure and should not be used as a reference standard.

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[1] Holland WW, Humerfelt S. Measurement of blood pressure. Comparison of intra-arterial and cuff values. *Br Med J* 1964;ii:1241-3.
[2] Beevers DG, Bloxham CA, Blackhouse CI, Lim CC, Watson RDS. The Remler M2,000 semiautomatic blood pressure recorder. *Br Heart J* 1979;42:366.
[3] Rose GA, Holland WW, Crowley EA. A sphygmomanometer for epidemiologists. *Lancet* 1964;i:296-300.
[4] Masterton G, Main CJ, Lever AF, Lever RS. Low blood pressure in psychiatric inpatients. *Br Heart J* 1981;45:442-6.
[5] Hunyor SN, Flynn JM, Cochineas C. Comparison of performance of various sphygmomanometers with intra-arterial blood pressure readings. *Br Med J* 1978;ii:159-62.

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