Pressure for change: unresolved issues in blood pressure measurement

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SUMMARY
The use of mercury is likely to be prohibited within a few years and clinicians have not yet seriously considered what sphygmomanometers they will use, nor is authoritative advice available on alternative instruments. Doubts also surround the thorny question of cuff size. Most blood pressures are taken in assessing cardiovascular health, and serial consulting room measurements may not be the best way of doing this. What is the role of continuous ambulatory monitoring in routine care? What is the place of home monitoring by patients, now that accurate and easy-to-use electronic sphygmomanometers are available?

Keywords: blood pressure measurement; blood pressure monitoring.

Introduction

BLOOD pressure is the commonest measurement made in clinical medicine, and the recommended instruments and techniques have been standardized[1,2] and regularly updated.[3,4,5] No official recommendations have been made on the choice of sphygmomanometer, and the most recent edition of the standard British work, the 1995 *ABC of hypertension,*[4] does not favour any one type. The mercury instrument is the gold standard however, and all other types are validated against it.

Environmental and technical developments will change blood pressure measurement in the next few years and four main problems will have to be addressed. First, the expected banning of mercury from clinical instrumentation for environmental reasons will lead to the removal of mercury sphygmomanometers from every consulting room, clinic, and ward. What will replace them? Secondly, the right cuff to use on each individual patient remains the subject of debate and disagreement among blood pressure experts, and the issue seems some way from resolution. Thirdly, the 24-hour ambulatory measurement of blood pressure is of obvious benefit in the assessment of problem patients, but what is its role in routine clinical care? And fourthly, now that accurate electronic sphygmomanometers are available, what is the place of home monitoring?

The mercury problem

Mercury was used in the earliest sphygmomanometers in the 1880s[6] and has stood the test of time. It is a particularly poisonous metal when ingested or when vaporized industrially or during illicit smelting. However, the regulations and procedures that have been adopted recently in health care premises have been intended to prevent mercury from getting into the environment through accidental spillage rather than to protect people against the very small risk of toxic effects should they become contaminated with it. There is no known risk to the user of any mercury-containing instrument, such as a sphygmomanometer, in normal clinical use, and the expected banning is based on the potential environmental danger from seabed and other pollution. This is an environmentally sound strategy in the long run, but at some stage there may be a rush to dispose of redundant sphygmomanometers; as far as I am aware, the greater potential for environmental contamination arising from irresponsible individuals throwing their devices into the dustbin has not been considered.

It has been said that the European Union will introduce a ban on the clinical use of mercury by the year 2000, but firm news is not yet available and this now seems unlikely. Sweden and Finland did ban mercury, in 1996, and France followed suit in 1997. There are no reports on what instruments have taken their place, but while visiting Scandinavia I found wall-mounted aneroid devices in many primary care premises. In mainland Europe, many more sales of the market-leading, semi-automatic sphygmomanometer are made to the general public than to the medical profession; in Britain, the opposite is true.

What will replace the mercury sphygmomanometer? Will it be the traditional hand-held or wall-mounted aneroid instrument, or the newer, semi-automatic, digital electronic version? Aneroid sphygmomanometers, which are used increasingly in the United States, are a simpler replacement and operate using familiar auscultatory mechanisms, but they are potentially inaccurate if not checked regularly: zeroing can become inaccurate, the mechanism can become corroded so that the falling pressure becomes jerky, and the aneroid chamber can leak; any of these faults can affect accuracy without the user being aware of them. The smaller circular dials on some of these instruments can also increase observer error.

Electronic instruments, however, measure blood pressure by changes, transmitted through the cuff, in the oscillometric patterns of arterial blood flow, and it has taken many years to accurately reproduce readings comparable to those from Korotkoff sounds. Accurate instruments of this kind[7,8,9,10] eliminate observer error and bias,[11] and are being increasingly used. They are more expensive than mercury or aneroid sphygmomanometers but have the advantage of being easier for patients to use for home monitoring, and some have the facility to calculate an average and print out a series of readings.

Clinicians in the United Kingdom are currently continuing to use mercury instruments, although informal enquiries to the trade indicate that recent sales of both the electronic and the aneroid devices are increasing. They are already supplanting the random zero instrument in many epidemiological studies. Whatever is chosen, some mercury devices against which to standardize all others will have to be retained.

The *ABC of hypertension*[4] stresses that the accuracy of any instrument used should be independently assessed, and that regular checks should be made. Various bodies, including the British Hypertension Society (BHS),[12] the American Association for the Advancement of Medical Instrumentation,[13] and the German authority (PTB),[14] all have standards for evaluating sphygmomanometers, though these refer mainly to automated ambulatory devices.

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- Borderline hypertension.
- Very labile blood pressure.
- Renal disease or diabetes if control is not optimal.
- Hypotensive or other symptoms possibly related to drug therapy.
- White coat hypertension revealed by home monitoring and treatment in doubt.
- Blood pressure control remaining poor despite other strategies.

Box 1. Indications for ambulatory monitoring.

The right cuffs

As early as 1901,[15] it was pointed out that too narrow a bladder within the cuff gave a falsely high blood pressure. Except when used with small children, 12cm is now the recommended bladder width for all cuffs.[4,16] This is so even for grossly obese patients because wider cuffs are difficult to wrap round very large upper arms; they also invade the antecubital fossa and interfere with auscultation.

Bladder length is more complicated. Although it is clear that too short a cuff gives erroneously high readings, while too long a cuff gives falsely low readings, the right length for a given upper arm circumference remains a matter of debate. The advice of the BHS in 1986,[1] and of the authoritative *ABC of hypertension* of 1987,[2] was that a length of 35 cm was appropriate for all arms, but that, if the bladder did not encircle the arm, then it was important that its centre should be over the brachial artery. By 1995, however, the BHS committee had decided that a bladder as short as 26 cm gives the most accurate readings for most adult arms.[4] This decision was partly the result of new evidence, and partly a response to problems arising from societies with thinner arms. Unfortunately, cuffs with bladders 26 cm long are not generally available. The BHS's most recent (1997) publication[16] expands on this recommendation to specify that arms exceeding 33 cm in diameter need a cuff bladder 40 cm long.

The evidence on which these recommendations on cuff length are based is not conclusive, and a final answer may be some way off.[17] A recent study comparing cuffs of 23 cm and 36 cm in length on arms of various sizes found mean differences of only 2.1 mm Hg systolic and 1.6 mm Hg diastolic.[18] The investigators found that these differences were little affected by arm size or level of blood pressure, and concluded that the size of the cuff is of minor importance in blood pressure measurement in comparison with other factors. Their study included only patients with arm circumferences between 25 cm and 40 cm, and they found no evidence that 'over-cuffing' underestimated blood pressure. Nor were they convinced by evidence that encircling the arm more than 100% causes underestimation, and they found no justification for recommending different cuffs for lean or obese arms. However, they used a normotensive population for their study and their results may not apply to hypertensive patients. Cuffs of similar dimensions have been compared using a semi-automatic instrument and only small differences were found, comparable to those of Bakx and colleagues; but differences were greater in patients with higher blood pressure (WitCH-Hunt Study, unpublished results).

Since routine arm measurement seems unlikely to become normal clinical practice,[17] and since most clinical work places will not have a range of cuffs of different lengths, my conclusion is that we should continue to use cuffs with a bladder 30 cm to 35 cm long, pay more attention to centralizing cuffs over the brachial artery, and try to become more aware of the thin and fat arms that are likely to be over- or under-cuffed. The commonly used cuffs with bladder lengths between 23 cm and 24 cm should be discarded. Meanwhile, manufacturers should respond to the evidence by producing cuffs of recommended dimensions and materials. The firmness of the backing material is important,[19] and washability is a desirable attribute.

Ambulatory monitoring

Ambulatory monitoring over 12-24 hours has become a valuable tool in the assessment and management of hypertension in some patient groups, and is routinely used in many hospital clinics (Box 1). Its value is acknowledged in the assessment of increased blood pressure variability, borderline hypertension, high-risk groups such as renal disease patients and some diabetics, poor blood pressure control, possible hypotensive symptoms due to antihypertensive medication, and in the diagnosis of 'white coat hypertension'.[4,5,20]

The approach has been little used in primary care, where most hypertensive patients in Britain are exclusively managed, because it is expensive and its value is not appreciated. Open access to a hospital service by primary care is often available, and one health authority has supplied devices on a trial basis to a large number of practices.[21] Correct use of these devices requires that nurses are trained in their use, adequate time is allowed for briefing patients, and specialized technical backup needs to be available. Acceptability problems arise with some patients,[22] and the BHS validation protocol requires data on patient acceptability.[12] Similar acceptability data are not currently required on semi-automatic instruments.

Raised blood pressure on ambulatory monitoring is more closely associated with left ventricular enlargement than that detected by office measurement, and it is now accepted as a better predictor of cardiovascular events.[4,5,11] How widespread the use of ambulatory monitoring becomes depends on several aspects besides those mentioned above. To what extent does it benefit the care of the average patient? Will the concept of examining blood pressure 'behaviour' rather than a succession of individual measurements become accepted? Some authorities believe that its use should be restricted to special cases,[5,20,23,24] while others assume that its more general use will prevail.[4]

Like many innovations in practice, uptake is likely to be sporadic and influenced by factors other than clinical need. The place of ambulatory monitoring in primary care will be better understood when the outcome of several ongoing studies become available. Of particular importance will be the results of the Oxford-based cohort study of more than 10 000 hypertensive patients, recruited in primary and secondary care, who are being followed up to determine the cardiovascular risks associated with different levels of ambulatory blood pressure.

Home monitoring

Sphygmomanometers have been used by patients at home for many years,[25,26,27] but this practice has been limited by the constraints of observer error and the necessity for training. The advent of semi-automatic devices has revolutionized this approach. Until recently, electronic instruments were inaccurate and unreliable,[28] but their validation[7,8,9,10] has put home monitoring within easy reach of all health carers and their patients. The sales explosion in Europe has been driven mainly by the general public, and there is an expanding market in both primary and secondary care in the UK and many other European countries.

The main use of home monitoring appears to be as an adjunct to the assessment of new hypertensive patients and those on treatment with poor blood pressure control.[29,30] Of particular value is its use to screen for sustained white coat hypertension in these groups.[31,32,33] For this specific purpose, it could be preferable to ambulatory monitoring[34] since it is highly acceptable to patients, who find it user-friendly and who are empowered to collaborate in their management in ways that ambulatory monitoring does not allow. Furthermore, it is easier to interpret, requires less staff training, and is considerably cheaper. However, it is a relatively new tool, and the full results of recent feasibility and acceptability trials are awaited (Aylett MJ, Marples G, Jones KP. WitCH-Hunt Study, International Society of Hypertension, Conference Proceedings, 1998).

Home monitoring is not, of course, a substitute for ambulatory monitoring, but the elucidation of their respective places in hypertension screening and management will be valuable. Most authorities seem to agree that both have an increasing role to play, and Pickering[35] has advised that all hypertensive patients should be screened for white coat hypertension by home monitoring before starting medication, and that those so diagnosed should be subjected to 24-hour ambulatory monitoring.

Normal values

Blood pressure levels outside the office or consulting room are generally lower, and reference values for ambulatory monitoring, based on large population studies, have been agreed.[36,37] Mean day-time figures are most commonly used and 'definitely hypertensive' thresholds exceeding 150/95 are suggested.[4] Home levels have been shown to be similar to ambulatory day-time ones.[37] Since levels for operational decisions vary depending on the presence of other cardiovascular risk factors, an alternative approach is to add correction factors in order to make figures comparable with office ones.

A review of a large number of publications has shown a usual difference between home and office mean levels of about 10 mm Hg systolic and 5 mm Hg diastolic, and these figures have been used by some workers.[33,37] Differences tend to be greater the higher the blood pressure. Although this is a helpful practical approach, it must be realized that it is a rough and ready rule and that, where doubt exists, particularly in diagnosing sustained white coat hypertension, greater reliance should be placed on office levels.

Conclusions

Precision in blood pressure measurement is less important in some clinical situations (in anaesthetics or casualty work, for example, where common observer errors such as terminal digit preference are usually of little clinical significance), but most measurements are concerned with the health of the cardiovascular system, and vital patient management decisions often hinge on changes in blood pressure that are dependent upon accurate recording. For instance, as many as 30% of cases of mild to moderate hypertension are thought to be misdiagnosed by observer error.[4] Up to a further 20% of those on treatment have sustained white coat hypertension,[38,39] and unless they have other major cardiovascular risk factors they do not need medication.[39,40,41,42,43] Yet this group is being ignored by most primary and secondary care workers, who should introduce either routine ambulatory or home monitoring of all hypertensive patients in order to diagnose these patients.[44]

Training in the measurement of blood pressure has, until recently, been seriously deficient in both the basic and the ongoing education of doctors and nurses, and every recent audit of knowledge or practice has shown serious deficiencies.[45,46,47] The major outstanding problems of blood pressure measurement represent a serious source of sub-optimal clinical practice.

- Continue using a mercury sphygmomanometer in the consulting room until officially advised to replace it. Semi-automatic electronic sphygmomanometers have some advantages over aneroid devices.
- Continue to use an aneroid instrument outside the consulting room.
- Consider using a semi-automatic electronic sphygmomanometer for home monitoring of all untreated or uncontrolled hypertensive patients.
- Use 30 cm or 35 cm cuffs.
- Consider referral for ambulatory monitoring of the patients detailed in Box 1.
- Screen all new and poorly controlled hypertensive patients for sustained white coat hypertension.
- Maintain a programme for checking all blood pressure equipment at least annually.
- Maintain a programme to update all clinical staff in blood pressure measurement.

Box 2. Conclusions and recommendations.

Provisional recommendations for resolving these problems are given in Box 2. It is hoped that some progress can be made before the inevitable next step: the move into blood pressure measurement in SI units. Kilopascals will be a further challenge indeed!

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