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Measuring blood pressure at the wrist: more comfortable for patients and more convenient for doctors?

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Objectives: To compare the agreement between conventional measurement of blood pressure and measurements obtained using two automated devices; and to compare how comfortable each of the three methods of measurement were for patients.
Methods: Blood pressure measurements and patient comfort scores were recorded using three different devices in 125-surgery and 40-community patients. The devices used were a conventional aneroid sphygmomanometer, an automated device that measured blood pressure on the upper arm and an automated device that measured blood pressure at the wrist. In each patient, the difference between the conventional and automatic measurement was calculated. The limits of agreement of each device were then calculated as the mean difference ± 1.96 standard deviations.
Results: In surgery patients, the width of limits of agreement of wrist measurement were 20.0 mm Hg and 12.1 mm Hg for systolic and diastolic blood pressure respectively, compared with 26.4 mm Hg and 27.7 mm Hg for automatic arm measurement. In community patients, the width of limits of agreement of wrist measurement were 11.6 mm Hg and 11.0 mm Hg for systolic and diastolic blood pressure respectively, compared with 19.5 mm Hg and 12.1 mm Hg for automatic arm measurement. Surgery patients also reported that wrist measurement of blood pressure was significantly more comfortable than either manual or automatic arm measurement (mean comfort scores 4.03 for automatic wrist and 2.13 for automatic arm measurement, Friedman's Test, $P < 0.001$).
Conclusions: Blood pressure measurements taken using the wrist device agreed more closely with those obtained using a conventional aneroid sphygmomanometer than the arm device. The wrist device was also more comfortable for patients than two other methods of blood pressure measurement.
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Introduction

Because telemedicine offers many potential benefits, it is becoming of increasing interest to many doctors, patients and policy makers.[1,2] These benefits include allowing medical records to be shared by health professionals located on different sites; speeding up the reporting of pathology tests, and the monitoring of patients from remote locations. At the Woodbridge Hill Surgery in Guildford, a telemedicine project[3] has been set up to improve the management of patients with heart failure in primary care. One of the key objectives of this project was to provide objective measures of patients' health status in their home environment, thus removing effects such as white coat hypertension.[4,5] Because manual recording of blood pressure by a health professional was not feasible in such a project, an automatic device was needed which can self-inflate, measure blood pressure, and produce a digital output suitable for transfer to the surgery via a phone line.

For the purposes of this telemedicine project, two automatic blood pressure measuring devices were available for use. One device measured blood pressure using a cuff inflated at the wrist. The second device measured blood pressure on the upper arm, in the same way as a conventional sphygmomanometer. We were free to choose either of these two devices, as both potentially could meet our needs.

Devices that measure blood pressure automatically on the upper arm are now in widespread use in the NHS but there is relatively little published work on the use of devices which measure blood pressure at the wrist. To help determine which device to use, we therefore reviewed previous research on the use of wrist devices. Only one published study was found. The findings of this study suggested that devices which measure blood pressure at the wrist may underestimate blood pressure in hypertensives and overestimate blood pressure in patients with hypotension.[6]

Because of the lack of previous work comparing the accuracy of measuring blood pressure at the wrist with measuring blood pressure on the upper arm, we undertook a study to compare measurements obtained with the automatic wrist and arm devices with conventional blood pressure measurement. We also assessed the acceptability of the three methods of blood pressure measurement to patients.

Methods

The study was carried out among the patients of the Woodbridge Hill practice in Guildford in April 1998. The Woodbridge Hill Surgery is a seven doctor practice with a list size of 11 500. The practice is one of the 15 practices that make up the South Thames Primary Care Research Network. Two groups of patients were studied; 125 consecutive patients attending the surgery for routine appointments and 40 consecutive patients in the community being visited by community nurses. We did this in order to

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evaluate the automatic devices in both general patients attending the surgery and the more infirm group of patients being visited at home by the community nurse. There were no exclusion criteria as we wished to test the devices on the usual range of patients seen by general practitioners and community nurses. In line with British Hypertension Society recommendations,[7] blood pressure measurements using the three methods were carried out at the same visit. The study received ethical approval from the West Surrey Local Research Ethics Committee.

Measuring devices

The automatic device that measured blood pressure on the upper arm was Conformité European (CE) marked. This means it should be fit for purpose and reliable (box).[8] The automatic wrist device was of American manufacture and hence did not have a CE mark. Three measuring devices were used.

Box. Conformité European (CE) marking
Background:
The main purpose of the marking is to bring about the completion of the Single Market by introducing harmonised and statutorily based controls to regulate safety and marketing of products throughout the European Community (EC).

What the marking means:
CE marking means that a manufacturer claims his product satisfies the requirements essential for it to be considered safe and fit for its intended purpose.

Is the device safe?
The CE marking ought to indicate that a device is safe, but should not be viewed as a guarantee of safety. Rather it should be seen as a declaration by the manufacturer that his product meets all the relevant provisions and has been assessed accordingly. The CE marking means that the product can be freely marketed anywhere in the community without further control.

(1) Conventional anaeroid sphygmomanometer. A new device, calibrated by the manufacturer (Accoson), was bought by the local community trust and supplied to the community nurse. The same piece of equipment was used by the practice nurse for patients seen at the surgery.
(2) Automatic upper arm device. Nais EW 284. This blood pressure device complies with the European regulations. The quality of the device has been verified and conforms to the European Council directive 93/42/EEC and the EEC directive 89/336/EEC.
(3) Automatic wrist device. Omron IC HEM 725CIC.

Measurement of blood pressure

One hundred and twenty five consecutive patients attending the surgery for routine appointments were invited to have their blood pressure checked by the study nurse after their appointment. To reduce inter-observer bias, the same nurse carried out all measurements. Blood pressure was first measured using a conventional anaeroid sphygmomanometer which had been newly purchased and recently calibrated. In line with the British Hypertension Society's guidelines. Korotkoff sounds phase one and phase five were used to identify systolic and diastolic blood pressure respectively. When the disappearance of sounds (Korotkoff phase five) could not be identified, the muffling of sounds (Korotkoff phase four) was taken as the diastolic blood pressure.[9] Blood pressure was then measured using the two automatic blood pressure devices in turn, with one measurement taken from the upper arm using the Omron device and one measurement taken from the wrist using the Nais device. There was no fixed order to the use of the two automatic blood pressure measurement devices. As blood pressure sometimes falls with sequential measurements in the same patient, using the automatic devices after the manual device may have led to a slight systematic under-recording of blood pressure with the two automatic devices.

Forty patients being visited by the practice's attached community nurse also had blood pressure measured using the same three methods as used in the surgery patients. In these patients the nurse carried out the manual measurement of blood pressure first, before asking the patient or carer to carry out the automatic measurement. An important objective of our telemedicine project was to determine if patients could carry out their own blood pressure monitoring. Hence, we needed to know if they could use the automatic blood pressure measuring devices and how their measurements agreed with those taken by the nurse. The nurse therefore gave instructions to each patient or their carer on how to carry out blood pressure measurement using the two automatic devices. The patients or their carers themselves then carried out the automatic measurements of blood pressure without any help from the nurse. The spouse or carers of the patients helped 20 of the patients with the automatic measurements of blood pressure.

Assessment of patient comfort

Patients were asked to score the level of comfort of blood pressure measurement on a five point linear scale where one was painful and five was comfortable. The surgery patients were asked about all three devices. The community patients were only asked about the two automatic devices, as self-measurement of blood pressure using a conventional sphygmomanometer would not be an option for remote monitoring of blood pressure.

Time taken to complete measurement

In five randomly selected surgery patients, the length of time taken to complete blood measurement with each different method was recorded. The recorded time included the amount of time the patient had to spend undressing for measurement of blood pressure at the level of the upper arm.

Statistical methods

The data were entered onto a Microsoft Excel spreadsheet and then transferred to SPSS (Statistical Package for the Social Sciences) for further analysis. The agreement between measurement with a conventional sphygmomanometer and the two automatic methods of measurement calculations was compared using the methods described by Bland and Altman.[10] Briefly, in each patient, the difference

between the conventional and automatic measurement was calculated. The limits of agreement of each device were then calculated as the mean difference ± 1.96 standard deviations. Finally, the statistical significance of differences in comfort between the three devices was assessed using Friedman's Test.

Results

All 125 surgery and 40 community patients successfully had blood pressure measured using each of the three methods. The patients seen in the community were significantly older than the patients seen in the surgery (mean age 65 versus 53 y, difference 12, 95% confidence interval 5 – 19 y).

Surgery patients

The automatic wrist measurement of blood pressure had substantially narrower limits of agreement with manual blood pressure measurement than did the automatic arm measurement (Table 1). For systolic blood pressure, the width of limits of agreement of wrist measurement was 20.0 mm Hg compared with 26.4 mm Hg for automatic arm measurement. For diastolic blood pressure, the respective width of the limits of agreement were 12.1 and 27.7 mm Hg. Patients reported that wrist measurement of blood pressure was significantly more comfortable than either manual or automatic arm measurement (mean comfort scores 4.56 for automatic wrist, 3.56 for manual arm and 3.22 for automatic arm measurement, Friedman's Test, $P < 0.001$, Table 2).

Community patients

As in the surgery patients, the automatic wrist measurement of blood pressure had substantially narrower limits of agreement with manual blood pressure measurement than did the automatic arm measurement (Table 3). For systolic blood pressure, the width of limits of agreement of wrist measurement was 11.6 mm Hg compared with 19.5 mm Hg for automatic arm measurement. For diastolic blood pressure, the respective width of the limits of agreement were 11.0 and 12.1 mm Hg. Community patients also reported that wrist measurement of blood pressure was significantly more comfortable than either manual or automatic arm measurement (mean comfort scores 4.03 for automatic wrist and 2.13 for automatic arm measurement, Friedman's Test, $P < 0.001$, Table 4).

Table 2 Distribution of comfort score in surgery patients

Comfort score	Manual measurement	Automatic wrist measurement	Automatic arm measurement
1 (discomfort)	1	0	6
2	8	1	23
3	51	6	43
4	50	39	43
5 (comfort)	15	79	10
Mean	3.56	4.56	3.22

Time taken to complete measurements

The mean time to complete the measurement of blood pressure was 70 s with the manual device, 93 s with the automatic wrist device, and 98 s with the automatic arm device. However, the amount of 'free' time during measurement of blood pressure was greatest with the wrist device. This took the least time to apply on patients as they did not have to undress and the nurse was able to carry out other tasks while the device measured the patients' blood pressure.

Discussion

For our telemedicine project, we needed an automatic blood pressure measuring device that middle aged or elderly patients could use at home either by themselves or with help from a carer. Despite the publication of recommendations about the evaluation of automatic blood pressure devices,[7] there was relatively little information available on the automatic wrist device we were considering using. Hence, we had to carry out our own evaluation before deciding which device would be most suitable for our purposes. Ideally, such evaluations should be carried out as part of the controlled introduction of new technology into the NHS, in line with previous recommendations on health technology assessment.[11,12]

As a result of this comparative study, we concluded that the device that measured blood pressure at the wrist was the most suitable for our purposes. Measurements taken with the wrist device agreed more closely with those taken using a conventional sphygmomanometer and patients also found the wrist device more comfortable to use. An additional benefit was that there was a potential time saving to the doctor in using the wrist device. We had also hoped that

Table 1 Mean differences and limits of agreement for manual and automatic methods of blood pressure management in surgery patients

Method	Mean difference (mm Hg)	Standard deviation (mm Hg)	Limits of agreement (mm Hg)
Systolic blood pressure			
Manual *vs* wrist	1.1	5.0	− 8.9 to 11.1
Manual *vs* arm	0.6	6.6	− 12.6 to 13.8
Diastolic blood pressure			
Manual *vs* wrist	1.7	3.0	− 4.4 to 7.7
Manual *vs* arm	0.7	7.0	− 13.1 to 14.6

Table 3 Mean differences and limits of agreement for manual and automatic methods of blood pressure management in community patients

Method	Mean difference (mm Hg)	Standard deviation (mm Hg)	Limits of agreement (mm Hg)
Systolic blood pressure			
Manual *vs* wrist	1.9	2.9	− 3.9 to 7.7
Manual *vs* arm	− 0.5	4.9	− 9.2 to 10.3
Diastolic blood pressure			
Manual *vs* wrist	1.9	2.8	− 3.6 to 7.4
Manual *vs* arm	0.5	3.1	− 5.6 to 6.6

Table 4 Distribution of comfort scores in community patients

Comfort score	Automatic wrist measurement	Automatic arm measurement
1 (discomfort)	0	8
2	0	19
3	8	13
4	23	0
5 (comfort)	9	0
Mean	4.03	2.13

using the wrist device could mean a saving of space on the clinician's desk. However, the instructions for the wrist device say that the wrist needs to be kept at the height of the left atrium. We discovered patients could only do this comfortably if they were supplied with a foam wedge onto which to rest their hand and arm.

The relative ease of accessibility of the wrist, compared with undressing a patient to expose their entire upper arm, made our preliminary study potentially of greater interest than just to those involved in telemedicine. The patients studied in both arms of our trial were unselected and typical of the patients being seen by general practitioners and community nurses. Our findings suggested that measuring blood pressure using the wrist device offer a potential time saving to clinicians. General practitioners are under great time pressure in their consultations with most general practice consultations lasting for between eight to ten minutes. Whilst there are no statistics for the number of blood pressure measurements made by general practitioners, there is a wide range of situations in which a patient's blood pressure needs to be measured. These include providing contraceptive services, and antenatal care, as well as managing hypertension heart and cerebrovascular disease, and opportunistic screening for raised blood pressure. In this context, freeing a small amount of time across a wide range of consultations could be of great benefit to general practitioners and practice nurses. For example, the time saved could be used to enter data on to the practice computer. Against these benefits have to be set the additional cost of the wrist device (£144 for wrist device, £85 for upper arm device, £45 for conventional anaeroid sphygmomanometer). As with most new technological devices, however, these differences in cost are likely to fall as sales of the wrist device increases.

We concluded that the wrist device was the most suitable for our telemedicine project. Because measuring blood pressure at the wrist was more comfortable for patients and quicker for the operator, clinicians, general practitioners and nurses could also consider using a wrist blood pressure measurement device in place of a conventional sphygmomanometer. Before this can happen, however, the wrist measuring device needs to be assessed further and the economic implications considered.

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