Chapter 3.4

Special blood pressure measuring devices

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Introduction

Sphygmomanometry has evolved over nearly three centuries, but conventional sphygmomanometry, the technique with which we are all so familiar in clinical practice, was introduced just over a century ago by Riva-Rocci [1]. However, as we enter the new millennium a number of developments, not least being the availability of accurate automated devices, herald the demise of so-called classic sphygmomanometry and the dawning of a new era in blood pressure measurement. This new age will see the introduction of innovative technologies that will allow not only accurate non-invasive measurement of blood pressure but also an assessment of blood pressure as a dynamic phenomenon, the effects of which are as dependent on the waveform and velocity characteristics as on the level of the generated pressure within the cardiovascular system.

Blood pressure measurement provides a figure, or set of figures, to the measurer, which then form the basis for a decision, the exact nature of which is influenced by the reason for measurement, which may be clinical, therapeutic, research, or epidemiological, just to mention a few of the more common requirements for blood pressure measurement. So the measurement technique is always 'special' at least to the measurer, who rightly demands accurate and reproducible results. In considering how best to define a 'special blood pressure-measuring device,' I have taken the view that what may be regarded as 'special,' or avant-garde today will be passé tomorrow, and that it is necessary therefore to view blood pressure measurement as an evolving discipline, albeit one subject to change. To appreciate the developments that are influencing measurement, it is necessary to identify the point of departure from an established technique to a new methodology. In short, we must be prepared to glance back before looking forward.

Traditional sphygmomanometry

When sphygmomanometry was first introduced, it was regarded as so innovative – so 'special' – as to have little future; one commentator, writing in 1895, while acknowledging that 'the middle-aged and successful physician may slowly and imperceptibly lose the exquisite sensitiveness of his finger tips through repeated attacks of gouty neuritis,' doubted if the sphygmomanometer would be welcomed by 'the overworked and underpaid general practitioner, already loaded with thermometer, stethoscope, etc., etc., …'[2]. And yet the technique, modified by Korotkoff's addition of the stethoscope in 1908, has lived on for over a century, earning the reputation of having contributed more to cardiovascular science than any other measurement technique in clinical medicine[3].

The technique, however, is now under threat mainly because of the proposed banning of mercury from clinical use, but also because automated devices can now provide measurements that are not subject to the observer error of the traditional technique. The environmental call

to ban mercury is because mercury is not merely a toxic substance but one that is bioaccumulable, and therefore persistently toxic. Much of the many tons of mercury supplied for the manufacture of sphygmomanometers and then distributed throughout the world to hospitals and countless individual doctors is never returned for disposal, but finds its way into the environment through evaporation, or dispersion in sewage and solid waste, most seriously damaging the marine environment. Ecologists and environmentalists resolved to reduce mercury in the environment to 'levels that are not harmful to man or nature before the year 2000'[1]. The mercury thermometer has been replaced in many countries, and in most Scandinavian countries and the Netherlands, where the use of mercury is no longer permitted in hospitals, the mercury sphygmomanometer is being relegated to the museum shelves. However, in other countries, the move to ban mercury from hospital use has been resisted – for the moment – on the grounds that the once common alternative, the aneroid sphygmomanometer, becomes inaccurate with use and should not, therefore, be substituted for the mercury instrument[1,4]. Of course, banning mercury from the wards raises another issue of considerable importance for clinical medicine: if we no longer have mercury, the argument that we measure what we see – the millimeter of mercury – is scarcely credible and the medical stance against its replacement with the *Système International* (SI) unit, the kilopascal, is no longer tenable[5,6].

The passing of the mercury sphygmomanometer should not in itself be a cause for concern. In fact, it might be argued that the sooner we rid ourselves of this most inaccurate technique, on which we base so many important decisions of management, the better. This is not to blame the mercury sphygmomanometer, but rather to impugn the most fallible part of the whole procedure – the human observer[7]. But if the mercury column is no longer available, what are the alternatives? In the past, the aneroid sphygmomanometers have been regarded as a reasonable substitute for the mercury sphygmomanometer, but because they become inaccurate with use without the operator being aware of such inaccuracy, and because they have not been subjected to independent validation, they are not generally recommended[8]. Automated devices, in their many guises, have performed badly in validation studies in the past[9], but recently, their record in this regard has been improving[10]. Before considering, therefore, how best to measure blood pressure without the mercury manometer, it is timely to review the state of the market in relation to automated devices in general.

The Working Group on Blood Pressure Monitoring of the European Society of Hypertension (ESH) published its recommendations on blood pressure measuring devices in the *British Medical Journal* (*BMJ*) in 2001 to guide the would-be purchaser through a complex market[10]. In the *BMJ* report, devices were assessed on the basis of published evidence of independent validation according to the British Hypertension Society (BHS) and Association for the Advancement of Medical Instrumentation (AAMI) protocols. The ESH is planning to update the *BMJ* report at regular intervals on its website.

Validation standards

In 1987, the AAMI published a standard for sphygmomanometers, which included a protocol for the evaluation of the accuracy of devices, and this was followed in 1990 by the protocol of the BHS[10]. Both protocols have since been revised[11,12], and as the two can be reconciled, the joint criteria are applied in most published validation studies. The criteria for fulfillment of the BHS protocol are that the test devices must achieve at least grade B for systolic and for diastolic pressures; the criteria for fulfillment of the AAMI protocol are that the test device must not differ from the mercury standard by a mean difference greater than 5 mmHg or a standard deviation greater than 8 mmHg.

Criteria for recommendation

The following criteria were used to designate devices according to accuracy in the *BMJ* report[10]:

'*Recommended*' – a device that fulfills the AAMI criteria for both systolic and diastolic pressures and achieves a BHS grade B or A for both systolic and diastolic blood pressures.

'*Not recommended*' – a device that fails the AAMI criteria for either systolic or diastolic pressure, and achieves a BHS grade C or D for either systolic or diastolic pressure.

'*Questionable recommendation*' – a device for which there is doubt about the strength of evidence, as may occur in the following circumstances: (i) when a device fulfills the criteria of one protocol but not the other, it may be best not to recommend the device for clinical use until a confirmatory study is performed; (ii) when the validation results are presented in abstract form only without sufficient detail being available to appraise the methodology, it may be best to withhold an opinion until the full results have been published, or at least provided to a would-be purchaser by the manufacturer; (iii) when the conditions of the protocols have not been fully adhered to (listed as 'protocol violation'); (iv) when a device fulfills the AAMI criteria for intra-arterial validation, it may be best to await a validation against indirect blood pressure measurement before recommending the device general clinical use; the BHS protocol does not advocate validation using direct intra-arterial measurement.

Identification of devices

The *BMJ* review was based on a follow-up of two previous surveys, and computerized search programs were used to identify validation studies in the literature up to December 1999. Blood pressure measuring devices were divided into two broad categories: *manual sphygmomanometers*, to include mercury and aneroid devices, and *automated sphygmomanometers*, to include devices for clinical use in hospitals, for self blood pressure measurement, and for ambulatory blood pressure measurement. With increasing pressure for a ban on mercury, a large market for alternative devices to the mercury sphygmomanometer has been created. Some devices for self-measurement

Table 3.4.1 Alternative devices to the mercury sphygmomanometer

Validated
1. Modified Omron HEM-705CP
2. Modified A & D UA-767
3. Omron HEM-907
4. WELCH ALLYN VITAL SIGNS monitor
5. BPM-100

Non-validated
6. GREENLIGHT 300
7. ACCUSPHYG
8. FINOMETER

of blood pressure have been successively modified for clinical use by increasing the length of tubing, and others are being developed but have not yet been validated; these devices are listed in Table 3.4.1[10].

Manual (mercury and aneroid) sphygmomanometers

These devices are listed in Table 3.4.2[10]. One model of the many mercury sphygmomanometers available, the PyMah, has been validated according to both protocols and was given the designation 'recommended.' As mercury sphygmomanometers generally adhere to a simple basic design with standard components, it is probably reasonable to assume that most, if not all, mercury sphygmomanometers would be of similar accuracy. The standard aneroid sphygmomanometer has only been formally validated recently according to the calibration procedure of the BHS protocol, and the results support reservations about aneroid devices because of their susceptibility to becoming inaccurate with use without this being apparent to the user.

Automated sphygmomanometers

Devices for clinical use in hospitals

These devices are listed in Table 3.4.3 [10].

Devices for self-measurement of blood pressure

There are a large number of automated devices for self-measurement of blood pressure, virtually all of which use the oscillometric technique. Formerly these devices used automated inflation and deflation of a cuff

Table 3.4.2 Manual devices which have been subjected to validation by the BHS and AAMI protocols. Grades A–D according to BHS protocol: A, best agreement with mercury standard; D, worst agreement with mercury standard. After O'Brien *et al*.[10]

Device	AAMI	BHS	Circumstance	Recommendation
PyMah Mercury	Passed	A/A	At rest	Recommended
Hawksley RZS: US model	Failed	B/D	At rest	Not recommended
Hawksley RZS: UK model	Failed	C/D	At rest	Not recommended
Aneroid device	n/a	Failed	In use; abstract only	Questionable recommendation

RZS = random zero sphygmomanometer; n/a = not applicable.

Table 3.4.3 Automated blood pressure measuring devices for clinical use in hospitals which have been subjected to validation by the BHS (devices must achieve at least grade B/B) and AAMI (mean difference ≤ 5 mmHg, SD ≤ 8mmHg) protocols. Grades A–D according to BHS protocol: A, best agreement with mercury standard; D, worst agreement with mercury standard. After O'Brien *et al*.[10]

Device	Mode	AAMI	BHS	Circumstance	Recommendation
Datascope Accutorr Plus	Osc	Passed	A/A	At rest	Recommended
CAS Model 9010	Osc	Passed	n/a	At rest in adults	Recommended
				Neonates	Recommended
Tensionic Mod EPS 112	Osc	Passed	B/A	At rest; abstract only	Questionable recommendation
Colin Pilot 9200	Tonometry	Passed	n/a	At rest; intra-arterial	Questionable recommendation
Dinamap 8100	Osc	Failed	B/D	At rest	Not recommended

Osc = oscillometric, Aus = auscultatory, n/a = not applicable.

Automated sphygmomanometers

Devices for self-measurement of blood pressure

Automated devices for upper arm measurement

applied to the upper arm over the brachial artery, but recently the technique has been used to measure blood pressure over the radial artery at the wrist; however, as they become inaccurate if the arm is not kept at heart level during measurement, there is reluctance to recommend them, regardless of accuracy.[10] Devices for measurement of blood pressure by occluding a digital artery in the finger are also available, but because the problem of limb position is even more critical and there is the additional problem of peripheral vasoconstriction affecting accuracy, this technique is no longer recommended, and these devices have not been considered in this review.

Automated devices for upper arm measurement

These devices are listed in Table 3.4.4[10].

Table 3.4.4 Automated blood pressure measuring devices for self-measurement of upper arm blood pressure which have been subjected to validation by the BHS (devices must achieve at least grade B/B) and AAMI (mean difference ≤ 5 mmHg, SD ≤ 8mmHg) protocols. Grades A–D according to BHS protocol: A, best agreement with mercury standard; D, worst agreement with mercury standard. After O'Brien *et al*.[10]

Device	Mode	AAMI	BHS	Circumstance	Recommendation
Omron HEM-400C	Osc	Failed	Failed	At rest	Not recommended
Philips HP5308	Aus	Failed	Failed	At rest	Not recommended
Philips HP5306/B	Osc	Failed	Failed	At rest	Not recommended
Healthcheck CX-5 060020	Osc	Failed	Failed	At rest	Not recommended
Nissei Analogue Monitor	Aus	Failed	Failed	At rest	Not recommended
Systema Dr MI-150	Osc	Failed	Failed	At rest	Not recommended
Fortec Dr MI-100	Osc	Failed	Failed	At rest	Not recommended
Philips HP5332	Osc	Failed	C/A	At rest	Not recommended
Nissei DS-175	Osc	Failed	D/A	At rest	Not recommended
Omron HEM-705CP	Osc	Passed	B/A	At rest	Recommended
Omron HEM-706	Osc	Passed	B/C	At rest	Not recommended
Omron HEM-403C	Osc	Failed	C/C	Protocol violation	Not recommended
Omron HEM-703CP	Osc	Passed	n/a	Intra-arterial	Questionable recommendation
Omron M4	Osc	Passed	A/A	Abstract only; detail missing	Questionable recommendation
Omron MX2	Osc	Passed	A/A	Abstract only; detail missing	Questionable recommendation
Omron HEM-722C	Osc	n/a	A/A	Protocol violation	Questionable recommendation
		Passed	A/A	Rest/elderly	Recommended
Omron HEM-735C	Osc	Passed	B/A	Rest/elderly	Recommended
Omron HEM-713C	Osc	Passed	B/B	At rest	Recommended
Omron HEM-737 Intellisense	Osc	Passed	B/B	At rest	Recommended
Visomat OZ2	Osc	Passed	C/B	At rest	Not recommended

Osc = oscillometric, Aus = auscultatory, n/a = not applicable.
Note in the first seven devices, grading criteria that had not been established though BHS protocol was in operation.

Table 3.4.5 Automated blood pressure measuring devices for self-measurement of blood pressure at the wrist which have been subjected to validation by the BHS (devices must achieve at least grade B/B) and AAMI (mean difference ≤ 5 mmHg, SD ≤ 8mmHg) protocols. Grades A–D according to BHS protocol: A, best agreement with mercury standard; D, worst agreement with mercury standard. After O'Brien *et al*.[10]

Device	AAMI	BHS	Circumstance	Recommendation
Omron R3	n/a	C/C	At rest; protocol violation	Not recommended
	Fail	D/D	At rest	Not recommended
Boso-Mediwatch	n/a	C/C	At rest; protocol violation	Not recommended
Omron Rx	Failed	B/B	At rest; abstract publication	Questionable recommendation

n/a = not applicable.

Automated devices for wrist measurement

These devices are listed in Table 3.4.5[10]. These devices have been validated against brachial arterial measurements.

Devices for ambulatory blood pressure measurement

There are two techniques for measuring ambulatory blood pressure: the commonly used method of intermittent measurement of blood pressure over the 24-hour period, and the developing method of continuous waveform analysis.

Devices dependent on intermittent blood pressure measurement

These devices are listed in Table 3.4.6[10]. Many of these devices have been validated in special groups, such as the elderly and pregnant women, and in differing circumstances, such as during exercise and in various postures.

Devices for continuous non-invasive finger blood pressure monitoring

The Portapres (TNO, Amsterdam), a portable recorder for 24-hour ambulatory monitoring, can provide beat-to-beat blood pressure monitoring that gives waveform measurements similar to intra-arterial recordings [10].

An automated alternative to mercury

From a review of the literature, it is evident that there are very many 'special' devices on the market, and that the accuracy of most of these has not been determined. Furthermore, of those that have been evaluated, rather few have fulfilled the requirements of the BHS and AAMI validation protocols.

Manufacturers of blood pressure measuring devices have failed to identify the need for reasonably priced accurate automated devices in clinical practice – a need which becomes all the more acute with the impending ban on mercury. Soundings from the manufacturing industry suggest that notice is now being taken of the need for an accurate

Table 3.4.6 Ambulatory blood pressure measuring devices which have been subjected to validation by the BHS (devices must achieve at least grade B/B) and AAMI (mean difference ≤ 5 mmHg, SD ≤ 8mmHg) protocols. Grades A–D according to BHS protocol: A, best agreement with mercury standard; D, worst agreement with mercury standard. After O'Brien *et al*.[10]

Device	Mode	AAMI	BHS	Circumstance	Recommendation
Accutracker II (30/23)	Aus	Passed	A/C	At rest	Not recommended
CH-DRUCK	Aus	Passed	A/A	At rest	Recommended
Daypress 500	Osc	Passed	A/B	At rest	Recommended
DIASYS 200	Aus	Passed	C/C	At rest	Not recommended
DIASYS Integra	Aus	Passed	B/A	At rest	Recommended
	Osc	Passed	B/B	At rest	Recommended
ES-H531	Aus	Passed	A/A	At rest	Recommended
	Osc	Passed	B/B	At rest	Recommended
Medilog ABP	Aus	Passed	n/a	At rest	Questionable recommendation
Meditech ABPM-04	Osc	Passed	B/B	At rest	Recommended
Nissei DS-240	Osc	Passed	B/A	Abstract only; detail missing	Questionable recommendation
OSCILL-IT	Osc	Passed	C/B	At rest	Not recommended
Pressurometer IV	Aus	Failed	C/D	At rest	Not recommended
Profilomat	Aus	Passed	B/A	At rest	Recommended]
	Aus	Passed	B/C	In pregnancy	Not recommended
Profilomat II	Osc	Failed	C/B	At rest	Not recommended
QuietTrak*[47–51]	Aus	Passed	B/B	At rest	Recommended
	Aus	Passed	B/B	At rest. Abstract	Questionable recommendation
	Aus	Failed	D/D	In preeclampsia	Not recommended
	Aus	Failed	B/B	In pregnancy	Not recommended
	Aus	Passed	A/A	At rest	Recommended
			A/A	During exercise	Recommended
			A/A	Different posture	Recommended
			A/A	In the elderly	Recommended
			A/A	In children	Recommended
			A/A	In pregnancy	Recommended
Save 33, Model 2	Osc	Passed	B/B	At rest	Recommended
Schiller BR-102	Aus	Passed	B/B	At rest	Recommended
	Osc	Failed	D/B	At rest	Not recommended
SpaceLabs 90202	Osc	Passed	B/B	At rest	Recommended
SpaceLabs 90207	Osc	Passed	B/B	At rest	Recommended
[64]	Osc	Passed	A/C	In pregnancy	Not recommended
[65]	Osc	Passed	B/B	In pregnancy	Recommended
[53]	Osc	Passed	B/C	In pregnancy	Not recommended
[57]	Osc	Failed	D/D	In pre-eclampsia	Not recommended
[66]	Osc	Passed	C/C	In pre-eclampsia	Not recommended
[67]	Osc	SBP pass	C	In children	Not recommended
		DBP fail	D	In children	Not recommended
[68]	Osc	Passed	A/B	Elderly standing and sitting SBP ≤ 160 mmHg	Recommended
[69]	Osc	Passed	A/D	Elderly supine over all pressures	Not recommended
	Osc	Passed	C/B	During hemodialyis	Not recommended
SpaceLabs 90217	Osc	Passed	A/A	At rest	Recommended
TM-2420/TM-2020	Osc	Failed	D/D	At rest	Not recommended
TM-2420 Model 6	Osc	Passed	B/B	At rest	Recommended
TM-2420 Model 7	Osc	Passed	B/B	At rest	Recommended
TM-2421	Osc	Passed	B/A	At rest	Recommended
Takeda 2421 [76]	Osc	n/a	C/C	In children and different posture	Not recommended
	Aus	n/a	A/B		Questionable recommendation [67]
Takeda 2430	Osc	Passed	A/A	At rest	Recommended

Osc = oscillometric, Aus = auscultatory, n/a = not applicable.

automated device for hospital and general practice, or put another way, manufacturers are becoming aware of the enormous potential market that will exist if mercury sphygmomanometers are phased out of use. There is an urgent need, therefore, for those involved in the management of hypertension to impress upon purchasing officers in the health services (whose responsibility it will be to order replacement automated devices for the traditional sphygmomanometer) that protocols are in existence for validating blood pressure devices, and that evidence of independent validation should be demanded from manufacturers. Again, soundings from hospital authorities suggest that there is presently a tendency to substitute aneroid for mercury sphygmomanometers without evidence as to the accuracy of these devices, especially after a period of time in use. Moreover, aneroid sphygmomanometry is prone to all the problems of the auscultatory technique, i.e., observer bias and terminal digit preference. Automated devices, by providing timed printouts of blood pressure, remove these sources of error and thereby improve the overall accuracy of measurement, provided, of course, that they themselves are accurate.

Of course, automation is not without problems. As already mentioned, automated devices have been notorious for their inaccuracy [9], and though accurate devices are now appearing on the market, they are not yet designed for hospital use, and their accuracy after a period of time in such use has not been established. Moreover, without the mercury standard against which to compare measurements generated by algorithmic interpretation of blood pressure, the clinician will become dependent on the consistency and accuracy of such algorithms. It will be necessary, therefore, to retain the mercury sphygmomanometer in certain laboratories as the gold standard against which algorithms may be checked from time to time.

What does the future hold?

At present automated blood pressure measuring devices rely, almost exclusively, on either auscultatory detection of Korotkoff sounds using one or more microphones, or oscillometric analysis of the pulse waveform. However, there has been such a significant shift from auscultatory to oscillometric devices in the last decade, it may be anticipated that in the near future, the microphonic recording of sounds will no longer be used [13]. What then of devices that utilize alternative measurement techniques to auscultation and oscillometry? The various methods of blood pressure measurement have been well reviewed by Ng and Small [13], to whom I am indebted for much of what follows. It may be anticipated that as technology develops, at least some of these innovative methodologies will be applied to the clinical detection of blood pressure. The majority of methods use a compressive cuff or bladder to fully, or partially, occlude an artery during the measurement process. All methods of measuring blood pressure can be further classified into intermittent or continuous measurement techniques. ECG gating techniques may be used to minimize artifact and thereby enhance accuracy.

Vascular unloading measurement

Also known as the volume-compensation, volume-clamp, and servo-plethysmomanometric method, this technique is based on the principle that if external pressure applied to an artery is equal to the arterial pressure at all times, the artery will be unloaded and cannot change in size. Usually a pneumatic finger cuff and plethysmographic transducer are used to detect changes in arterial volume. Using this technique of dynamic unloading of the finger arterial walls with an inflatable finger cuff incorporating a built-in photoelectric plethysmograph a continuous waveform of finger blood pressure can be obtained non-invasively over 24 or more hours. Known as the Finapres (FINger Arterial PRESsure), this device can be used to detect subtle changes in arterial pressure, which might be missed with intermittent pressure recording [14]. However, the transmission of the pressure pulse along the arm arteries causes distortion of the pulse waveform and depression of the mean blood pressure level, which results in poor comparative accuracy with the standard technique. The distorting effects of transmission on the pulse waveform may be reduced, and perhaps ultimately removed, by filtering techniques which are being developed at present. The unique value of the Finapres is attributable not to its accuracy when compared with traditional sphygmomanometry, but rather to the facility to assess beat-to-beat changes in blood pressure and the effect of various interventions and circumstances on blood pressure variability.

Applanation arterial tonometry measurement

Tonometry is based on the principle that if a superficial artery close to an underlying bone is partially flattened, or applanated with a fat rigid surface and kept in that state, the force exerted on the surface is nearly proportional to the pressure in the artery. This relationship can then be used to derive the relative arterial pressure waveform, which when calibrated against measurements made by a reference method (usually oscillometric pressure), yields absolute, continuous blood pressure measurement. The use of an array of sensors circumvents the practical difficulty of precisely positioning a single tonometer over the applanated artery [13].

Pulse-wave velocity (PWV) measurement

This method is based on the principle that the rate of propagation of pressure pulse waves along arteries – the pulse-wave velocity – increases with increasing arterial pressure. This relationship can be used to derive the relative arterial pressure waveform, which when calibrated against measurements made by the reference method, yields absolute, continuous blood pressure measurement. The PWV is usually computed from the pulse-transit time (PTT), which is the time it takes for a pulse wave to travel from one arterial site to another [13].

Infrasound measurement

This is a refinement of the auscultatory method in which the spectral energy of inaudible low-frequency Korotkoff vibrations is analyzed to detect blood pressure [13].

Ultrasound measurement

In this method, a piezoelectric transducer transmits ultrasound waves to an artery, while another transducer receives the reflected waves; blood pressure is determined from the frequency shift (Doppler effect) between the transmitted and reflected waves. The technique has been used extensively for measuring blood pressure in children [13].

Volume-oscillometric measurement

This method is similar to the oscillometric method except that it is based on arterial volume oscillations instead of cuff pressure oscillations [13].

Constant cuff oscillometric measurement

This method, developed by Cor Medical and sometimes called the COR method, is based on the principle that oscillometric pulses generated at a low, constant cuff pressure, give a complete waveform of oscillometric pulses, permitting continuous beat-to-beat arterial blood pressures to be measured, whereas the traditional oscillometric method is limited to a certain characteristic of the oscillometric pulses at different cuff pressures allowing only for intermittent measurement of blood pressure [13].

Pulse dynamic measurement

This method is based on oscillometry, but unlike traditional oscillometric techniques, in which calculations are dependent upon the amplitude and slope characteristics of the pulsation signal, the pulse dynamic method examines changes in the oscillometric signal. The pattern-recognition algorithm identifies the characteristic changes in phase which correspond to systolic, diastolic, and mean arterial pressures based on the dynamic effect of blood flow past the cuff (Bernoulli's effect) [14].

Sphygmooscillographic measurements

This method is also based on oscillometry; an algorithm derives the blood pressures from the amplitude and morphology of pulse waves recorded from a cuff transducer [15].

Pulse oximetry measurement

In this method the plethysmographic waveform derived from pulse oximetry measured on the finger is used to determine systolic blood pressure [16].

Arterial photoplethysmographic measurement

This method is based on photoplethysmographic signals derived from a large superficial artery during electrocardiographic-gated rapid removal of a previously applied occluding counterpressure [17].

Conclusion

We are moving into an age in which automated measurement of blood pressure will soon replace the conventional technique of sphygmomanometry. It may be anticipated that advances in computer technology will facilitate further the development of innovative measuring techniques. While welcoming these advances, clinical scientists must be prepared to examine such techniques critically and to ensure that accuracy does not fall victim to technological ingenuity.

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