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EDITORIAL

Blood pressure measurement in the year 2008: revival of oscillometry?

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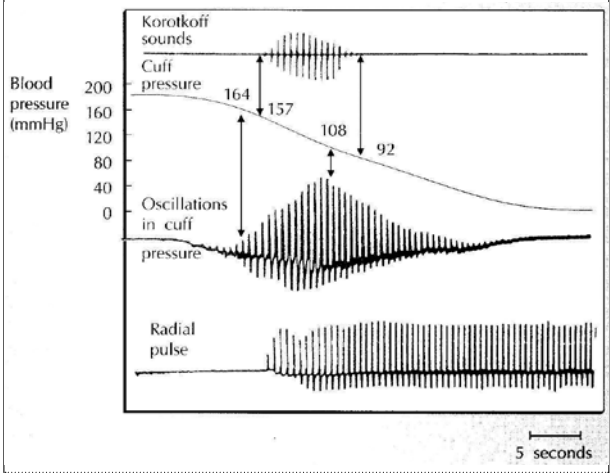
INTRODUCTION

In this issue of the Journal, attention is given to some aspects of blood pressure (BP) measurement by oscillometry.[1] In fact the oscillometric principle is a very old one and some of our elderly colleagues may remember the application in the oscillogram, used when a patient was suspected of having one-sided leg ischaemia. In such cases, oscillations in BP were different between the two legs, i.e. the affected leg showed oscillations with a smaller amplitude. When BP is measured oscillations are visible from suprasystolic to infradiastolic BP, but the oscillations show varying amplitude, as can be seen in *figure 1*, a well-known registration from the work of Geddes' group.[2]

Figure 1. *The oscillations when the pressure in the bladder decreases*



For comparison the blood pressure (BP) measurement according to the Korotkoff sounds is also given. In this model, the diastolic BP can be calculated from the mean arterial pressure (MAP) and the systolic BP, with the classic formula DBP = MAP – (SBP – MAP)/2, thus in the figure DBP = 108 – (164 – 108) /2 = 108 – (56 /2) = 80 mmHg.

HISTORY

In 1876, the French physiologist Marey reported that he had already been using the oscillometric method for 25 years.[3] At the time, the meaning of the maximal amplitude of the oscillations was hotly debated and a number of investigators, but not Marey himself, stated that the maximal amplitude was found at diastolic BP. The question then moved to the background due to the development of the Riva-Rocci/Korotkoff method for indirect BP measurement. In the late 1970s, new interest in oscillometric BP measurement arose mainly from work by anaesthesiologists,[4,5] who were looking for noninvasive methods to monitor BP in postoperative and/or intensive care patients. At that time there was more or less consensus that the oscillations with the maximal amplitude stood for the mean arterial blood pressure (MAP).

Then the aim shifted to deriving a systolic and a diastolic BP from the MAP. The algorithms of the (probably different) methods to calculate the systolic (SBP) and diastolic (DBP) were not disclosed and were sometimes changed without reporting that to users.

In another paper in this same issue of the Journal the Riva-Rocci technique is compared with the Korotkoff technique.[6] The next step may be to study the relation of the calculated SBP, derived from an oscillometric BP reading, with the two 'gold standards', namely the Riva-Rocci and the Korotkoff technique.

MEAN ARTERIAL PRESSURE

What were the advantages of using the MAP? The anaesthesiologists preferred to use one number for the BP when reporting the haemodynamic state of the monitored patient and the second was that with a MAP they could more easily calculate the total peripheral resistance (TPR) to have a

better idea about the balance between vasoconstriction and vasodilatation. But since most doctors and nurses are trained in measuring SBP and DBP and are accustomed to diagnosing and/or treating patients according to the limits for SBP and DBP given in guidelines, the MAP is not familiar enough to physicians, nurses and patients for everyday use. And thus, the situation has arisen that some devices used for self or home measurement that really measure the MAP only give the calculated SBP and DBP in the display with the consequence that sometimes the MAP is 're' calculated from the calculated SBP and DBP, as is also mentioned by Kiers *et al*.[1]

DIFFERENCE BETWEEN MEASURED AND CALCULATED MAP

Because, as stated earlier, the methods for calculating SBP and DBP are not published or revealed to the researchers in the field, it is no surprise that investigators compare the differences between the two MAPs, as has also been done by Kiers *et al*.[1] In our own experience large individual differences exist between calculated and measured MAP, which we illustrate in three hypertensive patients and in one normotensive individual (*tables 1* and *2*). On the other hand, when the number of readings increases, the correlation becomes stronger, although there are still individuals in whom the difference is of clinical importance. In *figure 2* the original (= measured) MAP and the calculated MAP are derived from the 24-hour registration and the correlation is very high, but in the lower panel the exceptional cases are still present.

Table 2. *Two additional examples in a normotensive and a hypertensive patient of the unpredictable relation between the similar measured MAP and the accompanying calculated SBP and DBP and consequently as MAP (c)*

MAP (M)	BP (C)	MAP (C)	M-C
131	167/97	120	11
	187/100	129	2
	178/102	127	4
	162/105	124	9
84	110/69	83	1
	137/58	84	0
	122/67	85	-1
	128/57	81	3

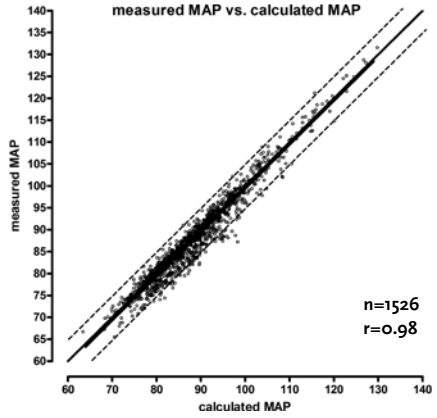
In the normotensive individual both MAPs are almost identical despite a large variation in the SBPs (27 mmHg) and DBPs (12 mmHg).
SBP = systolic blood pressure; DBP = diastolic blood pressure; PP = pulse pressure (SBP - DBP); HR = heart rate.

Table 1. *Two examples of the comparison of the measured (M) and the calculated (C) mean arterial pressure (MAP) within one continuous session of blood pressure measurements of two treated hypertensive patients*

MAP(M)	SBP	DBP	PP	MAP(C)	HR	M-C
Patient 1						
142	186	108	78	134	74	8
137	168	107	61	127	74	10
148	187	106	81	133	72	15
146	178	100	78	126	74	20
132	175	110	65	132	78	0
147	189	111	78	137	78	10
149	177	104	73	128	76	21
123	162	101	61	121	72	2
131	167	97	70	120	73	11
126	173	104	69	127	72	-1
129	159	101	58	120	75	9
Patient 2						
119	220	95	125	137	92	-18
120	182	84	98	117	73	3
105	198	84	114	122	72	-9
128	189	97	92	128	71	0
125	197	89	108	125	68	0
116	183	89	94	120	70	-4
116	195	80	115	118	69	-2
88	182	81	101	115	72	-27
107	195	90	105	124	67	-17

SBP = systolic blood pressure; DBP = diastolic blood pressure; PP = pulse pressure (SBP - DBP); HR = heart rate. C is calculated in the classical manner: MAP = DBP + 1/3 PP.

Figure 2. *The upper panel shows the correlation between original (= measured) and calculated mean arterial pressure (MAP), the lower panel shows a Bland-Altman plot of the same 1526 patients as in the upper panel*



Both MAPs are the means from the 24-hour recordings with about 40 to 80 readings. The unbroken line is x = y, the broken lines are the +5 and -5 mmHg.

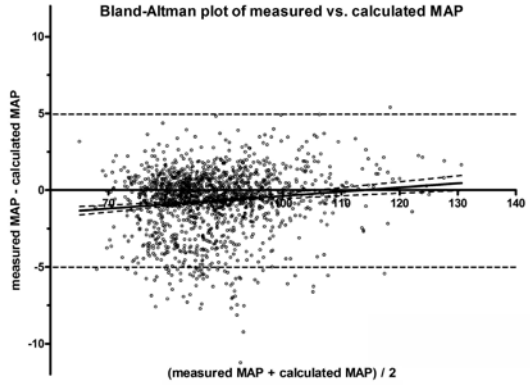


Table 3. *Comparison of the advantages and disadvantages of the three principles for the noninvasive measurement of blood pressure*

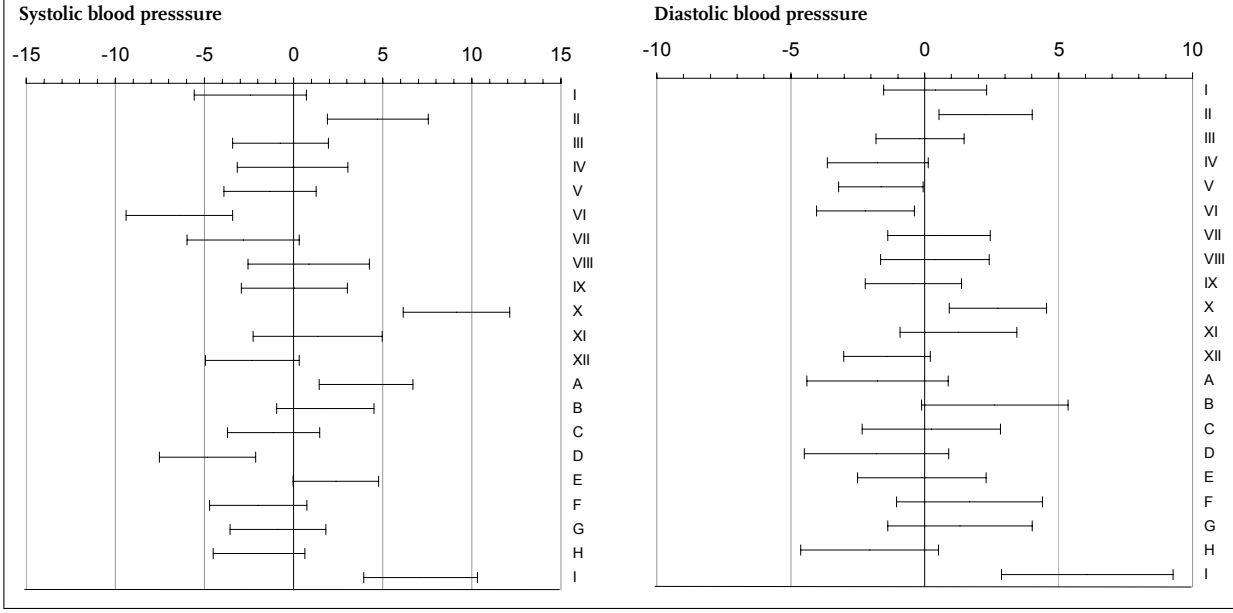
	Sphygmo-manometer + stethoscope*	Micro-phone	Oscillo-metry
Used in most inter-vention studies	Yes	No	No
Quality of hearing and stethoscope important	Yes	No	No
Stamping required*	Yes	No*	No*
Measures SBP and DBP	Yes	Yes	No
Measures MAP and calculates SBP/DBP	No	No	Yes
Sensitive to all kinds of bias**	Yes	No	No
Regular instruction and training needed	Yes	Yes	Hardly
Precision of bladder placement crucial	Yes	Yes	No
Bladder easily replaced after interruption	No	No	Yes

***Mercury is the gold standard: stamping is not needed, but normal regular inspection is useful; the mercury reservoir is filled sufficiently at zero level, the mercury tubes should be clean and there should be no leak in the air hoses. When an anaeroid sphygmomanometer is used besides the inspection as stated above also stamping is necessary at regular intervals, at least yearly. Whether the oscillometric and microphone devices need regular stamping is not yet known; regular inspection is of course useful (air hoses, batteries, printer etc.)**

****At least three kinds of bias: 1) digit preference, 2) the first reading influences the next etc., 3) memory of the results of the previous visit.**

SBP = systolic blood pressure; DBP = diastolic blood pressure; MAP = mean arterial pressure.

Figure 3. *The mean systematic deviation and the accompanying 95% confidence intervals for the 12 participating trained physicians (roman digits I to XII, upper part) and the same for the eight devices (A-I , lower part)[7], device I was a non-validated polse device*



DOES THE FUTURE BELONG TO THE OSCILLOMETRIC PRINCIPLE?

Despite the disadvantages mentioned above, there are important advantages to oscillometry, as listed in *table 3*. When, in the near future, the algorithms are improved and with the increase of home and self measurement of BP the digitalised oscillometric devices will win the competition. In *figure 3* an extra argument is demonstrated to illustrate this. The figure shows the individual means and 95% confidence intervals of BPs taken by 12 general practitioners well trained in measuring BP. BPs were measured in about 1200 patients.[7] The sometimes huge differences lead to pessimism about BP measurement by doctors and the effects of special training in BP measurement. It is tempting to conclude that in BP measurement the variation between doctors is as great as or even greater than the variation between devices, even though not all devices perform adequately. If the development in home and self measurement of BP continues, the future for oscillometric devices is bright, provided only devices that have fulfilled the criteria for accuracy according to the international guidelines are used.[8]

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ERRATA

In the special report 'Treatment of chronic hepatitis C virus infection – Dutch national guidelines', by J. de Bruijne *et al*. as published in Neth J Med. 2008;66(7):311-22, the dosing information of ribavirin was translated incorrectly. On pages 316 and 317, it should read 'weight-based ribavirin daily (1000 mg for <75 kg, 1200 mg for ≥75 kg)' instead of '800 mg ribavirin daily'. Please find below the correct information.

Antiviral therapy of HCV genotype 1

The treatment of HCV genotype 1 consists of the administration of peginterferon-α-2a 180 µg/week in combination with weight-based ribavirin daily (1000 mg for <75 kg, 1200 mg for ≥75 kg) or peginterferon-α-2b at a weekly dose of 1.5 µg/kg in combination with weight-based ribavirin (800 mg from ≤65 kg, 1000 mg from 65 to 85 kg, 1200 mg from 85 to 105 kg and 1400 mg from ≥105 kg) (*tables 7* and *8*).

Antiviral therapy of HCV genotype 4

The treatment of HCV genotype 4 consists of the administration of peginterferon-α-2a 180 µg/week in combination with weight-based ribavirin daily (1000 mg for <75 kg, 1200 mg for ≥75 kg) or peginterferon-α-2b at a weekly dose of 1.5 µg/kg in combination with weight-based ribavirin (*tables 7* and *8*).