Does changing from mercury to electronic blood pressure measurement influence recorded blood pressure? An observational study

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SUMMARY

Mercury sphygmomanometers have been commonly used in primary care to measure blood pressure but are associated with bias. Electronic blood pressure machines are being introduced in many practices and have anecdotally been associated with higher recorded blood pressure. This study examined recorded blood pressure in four practices before and after electronic blood pressure machine introduction. No consistent change in mean blood pressure was apparent following their introduction, but there was a large and significant fall in terminal digit preference suggesting improved precision of recording.

Keywords: *blood pressure; blood pressure determination; blood pressure monitors; diagnostic equipment; measurement; sphygmomanometers.*

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Introduction

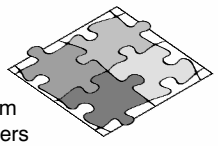
GENERAL practitioners (GPs) and practice nurses commonly measure blood pressure in primary care using mercury sphygmomanometers, a time consuming practice with important potential for error. Mercury sphygmomanometers are due to be phased out following a European Union mercury ban and as affordable validated electronic machines become available.[1,2]

Known sources of error in blood pressure measurement include: instrument error, operator error, and patient error.[3] Changing to electronic blood pressure measurement might reduce operator error caused by terminal digit preference (rounding to the nearest 10), threshold bias (rounding below a treatment threshold), and poor technique. This is important; one study examining the effect of threshold bias found that women with a recorded diastolic blood pressure just below treatment threshold (88 mmHg) had higher mortality rate than women with blood pressure recorded above the threshold (90–99 mmHg).[4] However, anecdotal reports suggest that changing to electronic measurement may lead to higher recorded blood pressures.[5] No robust data from clinical practice exist. This study aimed to evaluate the impact of electronic sphygmomanometers in routine primary care by comparing readings recorded before and after the introduction of such machines.

Method

Anonymised computerised blood pressure data for the period 1999–2001 were collected from four practices within the Midlands Research Practice Consortium. We grouped the data into three periods (time period 1: August 1999–April 2000; time period 2: May 2000–January 2001; time period 3: February 2001–October 2001). Practice 1 used electronic measurement throughout, practices 2 and 3 changed to electronic measurement in May 2000, and practice 4 changed to electronic measurement in February 2001. Only patients who had a blood pressure measurement taken in each period were included in the study. Where more than one reading had been taken in a time period, the last recorded reading was used. All practices used Omron electronic blood pressure machines (HEM-705CP or HEM-711AC), although mercury machines were available even after the practices changed. Large and standard cuffs were available for both types of sphygmomanometers. Data were analysed with SPSS for windows (version 10.0) to investigate any changes in mean blood pressure readings and changes in the proportion of blood pressure readings with a terminal digit of zero across the three time periods in each practice.

HOW THIS FITS IN



What do we know?

Many general practices are switching from mercury to electronic sphygmomanometers but no robust evidence exists regarding the impact of this change.

What does this paper add?

This study suggests that the use of electronic blood pressure measurement improves the precision of recording without leading to changes in mean recorded blood pressure.

A minimum of 170 readings for each practice were needed to be able to detect a 15% change in the proportion of readings recorded with a terminal digit of zero at 80% power.

The study was approved by the South Birmingham Local Research Ethics Committee.

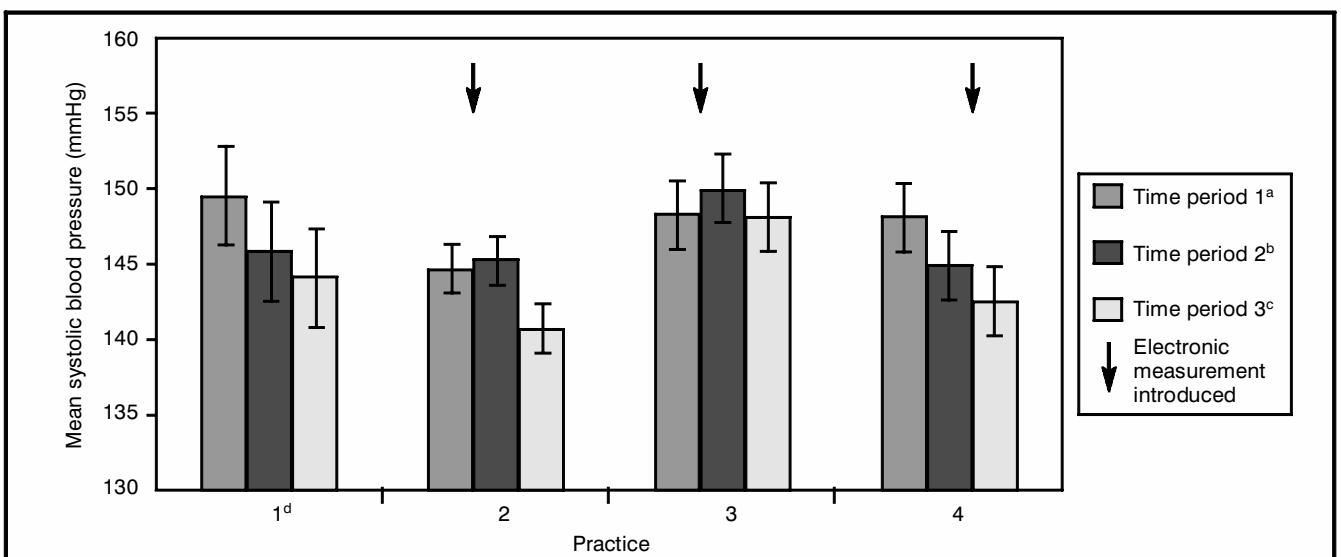
Results

Blood pressure readings from 1521 patients were included, of whom 874 were coded with a diagnosis of hypertension. There was no consistent change in mean systolic or diastolic blood pressure associated with the introduction of electronic sphygmomanometers, although there appeared to be a

Table 1. Mean systolic and diastolic blood pressures (mmHg) in time periods 1–3 with mean differences.

Practice	Number of readings (*n*)	Mean BP for TP 1 (mmHg)	Mean BP for TP 2 (mmHg)	Mean BP for TP 3 (mmHg)	Mean difference in BP for TP 2 - 1 (mmHg) (95% CI)	Mean difference in BP for TP 3 - 2 (mmHg) (95% CI)
Systolic						
1	179	149.6	145.9	144.1	-3.7 (-0.3 to -7.1)	-1.8 (1.2 to -4.7)
2	489	144.7	145.2	140.9	0.5 (2.3 to -1.26)	-4.3 (-2.5 to -6.1)
3	476	148.3	149.9	148.1	1.6 (3.7 to -0.4)	-1.8 (0.2 to -3.9)
4	377	148.2	145.0	142.3	3.2 (1.2 to 5.2)	-2.7 (-0.6 to -4.7)
Diastolic						
1	179	84.3	83.7	82.1	-0.6 (1.3 to -2.6)	-1.6 (0.2 to -3.3)
2	488	83.5	82.9	80.8	-0.6 (0.3 to -1.5)	-2.1 (-1.1 to -3.2)
3	474	83.0	84.2	84.4	1.2 (2.3 to 0.1)	0.2 (1.3 to -0.8)
4	377	83.3	80.4	80.9	-2.9 (-1.7 to -4.1)	0.5 (1.5 to -0.7)

BP = blood pressure. TP = time period.



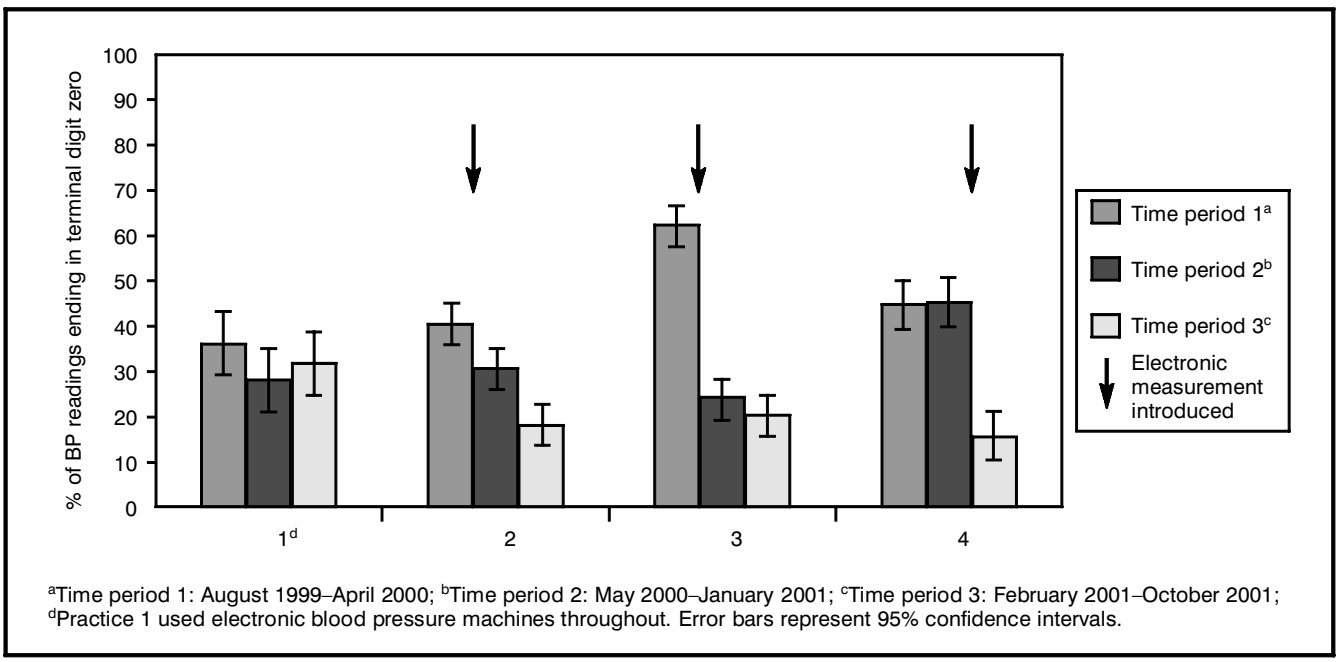
[a]Time period 1: August 1999–April 2000; [b]Time period 2: May 2000–January 2001; [c]Time period 3: February 2001–October 2001; [d]Practice 1 used electronic blood pressure machines throughout. Error bars represent 95% confidence intervals.

Figure 1. Mean systolic blood pressure in four practices.

Table 2. Proportion of readings ending with terminal digit zero.

Practice	Number of readings (*n*)	BP readings with zero terminal digit in TP 1 (%)	BP readings with zero terminal digit in TP 2 (%)	BP readings with zero terminal digit in TP 3 (%)	Mean difference in % zero terminal digit for TP 2 - 1 (95% CI)	Mean difference in % zero terminal digit for TP 3 - 2 (95% CI)
Systolic						
1	179	36.9	28.5	32.4	-8.4 (0.7 to -17.5)	3.9 (13.5 to -5.7)
2	489	40.7	31.1	18.4	-9.6 (-3.7 to -15.5)	-12.7 (-7.5 to -17.9)
3	476	62.0	25.0	20.8	-37 (-31.2 to -42.8)	-4.2 (0.9 to -9.2)
4	377	45.6	46.2	17.5	0.6 (7.5 to -6.3)	-28.7 (-22.4 to -35.0)
Diastolic						
1	179	27.4	32.4	27.9	5.0 (14.5 to -4.5)	-4.5 (4.5 to -13.5)
2	489	33.3	18.6	15.7	-14.7 (-9.3 to -20.1)	-2.9 (1.9 to -7.7)
3	476	48.7	23.5	21.6	-25.2 (-19.3 to -31.1)	-1.9 (3.1 to -6.9)
4	377	56.5	58.9	15.6	2.4 (9.3 to -4.5)	-43.3 (-37.2 to -49.4)

BP = blood pressure. TP = time period.



[a]Time period 1: August 1999–April 2000; [b]Time period 2: May 2000–January 2001; [c]Time period 3: February 2001–October 2001; [d]Practice 1 used electronic blood pressure machines throughout. Error bars represent 95% confidence intervals.

Figure 2. Proportion of blood pressure readings with terminal digit zero in four practices.

trend towards lower blood pressure over time (Figure 1 and Table 1). Similar patterns were seen in patients labelled as hypertensive or not, and in those with higher blood pressure compared with lower (not shown). A large and significant change was seen in the terminal digit preference for zero at the time of conversion to electronic sphygmomanometers (McNemar's test $P < 0.01$ after Bonferroni correction in each case) (Figure 2 and Table 2). This change was equally apparent in systolic and diastolic blood pressure and was not seen in practice 1, which had converted to electronic sphygmomanometers prior to the period of investigation.

Discussion

Introduction of electronic blood pressure machines led to an improvement in the precision of recorded blood pressure, as seen by the reduction in terminal digit preference, with no consistent significant effect on mean recorded blood pressure. This suggests that, although rounding of blood pressure was taking place previously, practitioners rounded up as well as down. About 20% of readings continued to end in a zero suggesting that despite the use of electronic sphygmomanometers (which display blood pressure to the nearest

1 mmHg), either an element of rounding continued or mercury sphygmomanometers, which read to the nearest 2 mmHg, were being used for at least a proportion of blood pressure measurements.

Increasing the precision of blood pressure recording is worthwhile. The implication of the finding by Wingfield *et al* that mortality was worse in people with blood pressure recorded just below a treatment threshold, was that their true blood pressure was higher and that they would have benefited from blood pressure-lowering therapy.[4]

The trend towards lower blood pressures over time may have been caused by a number of factors including accommodation to the method of measurement, regression to the mean, or more intensive treatment, and is similar to that seen in the Health Survey for England, albeit over a shorter period of time.[6] Other factors may have influenced recorded blood pressure in this study. The publication of the British Hypertension Society guidelines in 1999[7] may have led to more intensive treatment that masked the effects of switching to electronic sphygmomanometers. A relatively short timescale has been studied and it may be that longer-term effects have been missed. It is possible that small changes in blood pressure have been missed in this study owing to type 2 error, although the sample sizes achieved are large enough to detect a 5 mmHg difference in systolic blood pressure at 80% power.

Apart from a small uncontrolled series of readings in one practice, there is little published literature on the effect of the introduction of electronic sphygmomanometers in general practice.[5] This study suggests that the effect will be to improve precision without leading to changes in mean recorded blood pressure.

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Acknowledgements

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