Measurement of Blood Pressure

Ambulatory and Home Blood Pressure Monitoring

BHS Non Medical Prescribing Update
MSc. Management of Hypertension in Primary Care
University of Birmingham
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Topics to be covered

• Blood pressure monitors
• Gold standard blood pressure measurement
• Quality control
• Ambulatory blood pressure monitoring
• Home blood pressure monitoring
• Basic interpretation of results
Background

• BP is an accurate predictor of cardiovascular morbidity and mortality
• Accurate and reproducible measurement is an important clinical skill
• Diagnosis and future management plans based ultimately on readings obtained
• Inaccurate readings lead to:
  - Incorrect diagnosis
  - Inappropriate treatment and follow up
Are you using the correct blood pressure equipment to assess your patient?
STOP!!

Feel the pulse

Is it regular?
Use automatic monitor

Is it irregular?
Use manual monitor: ABPM/HBPM not recommended
Guidance to all involved with the purchase, management and use of non-invasive blood pressure measurement devices

The topics covered are:
• Types of blood pressure measurement equipment
• Sources of error and other issues
• Purchase, training and maintenance
• Mercury

http://www.mhra.gov.uk/Publications/Safetyguidance/DeviceBulletins/CON2024245
Mercury Sphygmomanometer

• Concerns about toxicity (esp. spillage) and environment

• Maintenance is difficult

• By 2014 Mercury Sphygmomanometers will only be sold for use in clinical trials and reference standards for clinical validation studies

(Commission regulation(EU) no 847/2012)
Aneroid Sphygmomanometer

- Aneroid (gr) = containing no liquid
- More easily damaged and lose calibration easily
- Desk mounted or attached to hand bulb
Electronic Manual
Sphygmomanometers

- A pressure sensor and electronic display replaces the mercury manometer
- The display may be a numerical display or a circular or linear bar graph
- Devices zero calibrate before each measurement
- Less prone to loss of calibration
Riva-Rocci / Korotkoff Technique

• Involves cuff occlusion of brachial artery

• Various sounds heard in stethoscope over brachial artery – Korotkoff sounds – as cuff is deflated

- Systolic BP = Phase 1
- Diastolic BP = Phase 5

<table>
<thead>
<tr>
<th>Phase of Sounds</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>First appearance of sounds</td>
</tr>
<tr>
<td>2</td>
<td>Softening or disappearance of sounds</td>
</tr>
<tr>
<td>3</td>
<td>The reappearance of sounds</td>
</tr>
<tr>
<td>4</td>
<td>Muffling of sounds</td>
</tr>
<tr>
<td>5</td>
<td>The final disappearance of sounds</td>
</tr>
</tbody>
</table>
Oscillometric Monitors

- First demonstrated in 1876
- Oscillations of pressure in a cuff are recorded during deflation – point of maximal oscillation = MAP
- Oscillations begin approximately at sBP and continue below dBP
- sBP and dBP can only be estimated indirectly by an empirically derived formula
- Can be subject to errors with mechanical vibration
- Not reliable in cardiac arrhythmias i.e. atrial fibrillation
Wrist-based Devices

- Oscillometric wrist devices are comfortable and easy to use
- Wrist devices are subject to errors that are not presently evaluated in the available validation protocols
- The most important source of error with wrist devices is the position of the arm in relation to the heart

“A wrist device may fulfil the accuracy criteria of a validation protocol when strict attention is paid to having the wrist at heart level but in home use this may not happen and as a consequence the measurement can become inaccurate. For this reason validated upper arm devices are recommended in preference to wrist devices” (BHS)
Ambulatory Blood Pressure Monitors

- Started in the 1960s
- Measures BP at regular intervals, with patients undertaking their usual activities
- Emphasis on mean daytime pressure, which is better predictor of cardiovascular risk and target end organ damage than clinic readings
- ABPM provides more information than either home or clinic BP measurement because more readings taken
Monitors

For a list of independently validated monitors go to the British Hypertension Society website

www.bhsoc.org.uk
Cuff Size: Get it right!

Small Adult: 17-26cm
Standard Adult: 24-32cm
Large Adult: 32-42cm
Extra Large Adult: 38-50cm

Bladder too SMALL = under cuffing
= overestimation of BP

Bladder too LARGE = over cuffing
= underestimation of BP
Quality Control Measures

- Check hoses, valves and cuffs regularly and document dates.

- Excessive air leakage from damaged cuffs, tubing or connectors will reduce the accuracy of the blood pressure measurement.

- A named HCP should be accountable for this process.

- Ensure all HCPs undertaking measurements are adequately trained and competence re-evaluated.
How to Measure BP 1
(using manual or automatic device)

• Measure sitting blood pressure routinely

• Measure in both arms at 1\textsuperscript{st} visit. Measure future BP in highest arm if >20/10 mmHg difference. Document

• Ideally the patient should not have exercised, eaten or smoked for at least half an hour prior to taking BP
How to Measure BP 2
(using manual or automatic device)

• The patient should be seated for at least 5 minutes, relaxed and not moving or speaking

• Remove tight clothing, support arm at heart level, ensure arm relaxed and avoid talking (patient and HCP) during the measurement

• When using manual monitor, estimate systolic blood pressure, lower column slowly (2 mmHg per second) and read blood pressure to the nearest 2 mmHg
• If BP > 140/90mmHg, take another measurement, with a minute interval between measurements

• If the second measurement is substantially different to the first, take a third reading

• Record the lowest of the last 2 measurements as the clinic BP
Lying Standing BP

- Lying Standing BP should be measured in the elderly and in diabetic patients at initial assessment and in patients whose symptoms or drug regime may be associated with a disproportionate drop in BP.

- Measure BP with the person either supine or seated. Stand, then measure BP again after standing for a minute.

- If \( \geq \) or greater than 20mmHg difference in standing BP:
  - review medication
  - measure BP when standing in subsequent visits

NICE Clinical Guideline 127 (2011)
How to record BP

• Correct entry in multidisciplinary notes is important

• How, what, where, & when of measurement

• Cuff size used

• Interarm BP difference

(i) position of the individual – lying, sitting or standing
(ii) the arm in which the measurement will be made – right or left
(iii) blood pressure in both arms on first attendance
(iv) arm circumference and inflatable bladder size
(v) phases IV and V for diastolic blood pressure
(vi) an auscultatory gap if present
(vii) state of the individual – e.g. anxious, relaxed
(viii) time of drug ingestion.
If the clinic blood pressure is 140/90 mmHg or higher, offer ambulatory blood pressure monitoring (ABPM) to confirm the diagnosis of hypertension.
Further Benefits of Undertaking ABPM

- Assessment of BP variability
- Diagnosis and ongoing assessment of white coat hypertension or effect
- Evaluation of drug-resistant hypertension
- Determining the efficacy of drug treatment over 24 hours
- Diagnoses and treatment of hypertension in pregnancy
- Evaluation of symptomatic hypotension
ABPM for Diagnosis of Hypertension

When using ABPM to confirm diagnosis ensure:

- at least 2 measurements per hour during the person’s usual waking hours

- an average of at least 14 day time measurements are used to confirm diagnosis
Hypertension

Implementation advice

Implementing the ambulatory blood pressure monitoring recommendations
Monitors

- Independently validated monitors
- Software and IT support
- Service/ maintenance and calibration
- Batteries – how many times can they be used?
- Non return of monitors
# Cuffs

- **Cuffs** – use correct size

<table>
<thead>
<tr>
<th>Category</th>
<th>Size Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child</td>
<td>13 - 20cm</td>
</tr>
<tr>
<td>Small Adult</td>
<td>17 - 26cm</td>
</tr>
<tr>
<td>Adult</td>
<td>24 - 32cm</td>
</tr>
<tr>
<td>Large Adult</td>
<td>32 - 42cm</td>
</tr>
<tr>
<td>Ex Lg Adult</td>
<td>38 - 50cm</td>
</tr>
</tbody>
</table>

- **Washing!!!** – consider local Infection Control Policy [HSG 95(18) Hospital Laundry Arrangements for Used and Infected Linen]
Fitting

- Devise local SOP and competences for health care professionals fitting monitors
- Devise local audit standard for percentage of successful readings
- Devise local documentation/safety check list
- Allow 20-30 minutes for fitting
- Which arm – determine if significant inter arm difference
  - $\leq 20$ mmHg difference use non dominant arm
  - $> 20$ mmHg difference use arm with higher blood pressure
Caution

- Anti-coagulated patients
- CVA affected limb
- Mastectomy / lymphoedema
- Injury
- Friable skin
- Latex allergy
- Infection control issues
- Patient suitability to undertake procedure
Patient Advice 1

Instruct patient to:

• undertake normal activities
• stand still and don’t talk during measurement
• keep their arm supported during measurement
• keep monitor attached at night if undertaking 24 hour monitoring (place under pillow/to side)
• keep monitor dry
• limit cardiovascular exercise
• record relevant diary events
Patient Advice 2

Explain procedure:

- frequency of inflation
- length and duration – when to turn off / return to clinic
- unsuccessful readings – check for kinked tubing, excessive movement and/or talking
- monitor failure – what to do
Patient Advice 3

Safety precautions:

• bruising / pain / swelling – remove monitor
• how to manually deflate the cuff
• work – consider hazards and consult local Health and Safety policy
Driving and ABPM

• 2 Independent insurance companies have confirmed that they would not cover a driver whose accident occurred while wearing a ABPM monitor
• Patients should be advised that driving motorised vehicles or motorcycles should be avoided or kept to a minimum
• If driving is unavoidable patients should switch the monitor off after the last reading before starting their journey and switch it back on when they have arrived at their destination
• Professional drivers should choose a non-driving, but still an active day
Devise local advice sheet for patient reference to include contact telephone numbers

BHS now have Ambulatory Blood Pressure Monitoring resource on website
Home Blood Pressure Monitoring

Use **home blood pressure monitoring** to confirm diagnosis when ABPM unavailable, refused or not tolerated

• Record two consecutive seated measurements, at least 1 minute apart
• Record blood pressure twice daily, ideally in the morning and evening
• Record for at least 4 days and preferably for a week
• Discard measurements recorded on the first day
• Calculate the average of all remaining readings

NICE Clinical Guideline127 (2011)
Home Blood Pressure Monitoring

- If using patients own monitor ask them to bring in their monitor to the next appointment
- Check that the machine is an independently validated model and is calibrated as per manufacturers requirements
- Check that they are using the correct size cuff
- Ensure that the patient knows how to use the machine
- Ask the patient to complete a measurement during the appointment, following the same advice as described earlier for accurate clinic measurements
- Advise on battery life and how to maintain the cuff and machine
Home Blood Pressure Monitoring

- Show the patient how to record the readings..... monitor memory data may be inaccurate (other family members may use the monitor!)
- Devise local documentation for recording of results
Basic Interpretation of Home and Ambulatory Blood Pressure Measurements
Definitions (Diagnosis)

Stage 1 hypertension:
• Clinic blood pressure (BP) is 140/90 mmHg or higher and
• ABPM or HBPM average is 135/85 mmHg or higher.

Stage 2 hypertension:
• Clinic BP 160/100 mmHg is or higher and
• ABPM or HBPM daytime average is 150/95 mmHg or higher.

Severe hypertension:
• Clinic Systolic BP is 180 mmHg or higher or
• Clinic Diastolic BP is 110 mmHg or higher.

NICE Clinical Guideline 127 (2011)
White Coat Hypertension

• A persistently elevated clinic BP and a normal home or ambulatory BP day time average i.e. < 135/85mmHg

• Expected 10/5mmHg difference in ABPM and HBPM readings when compared to clinic BP

• Review clinic blood pressure values when interpreting the ABPM
White Coat Effect

- In people with true hypertension, treated or untreated, a clinic BP that is disproportionately greater than their home or ambulatory BP averages but their home or ambulatory readings are within the hypertensive range.

- A discrepancy of more than 20/10 mmHg between clinic and average daytime ABPM or average HBPM blood pressure measurements at the time of diagnosis.

NICE Clinical Guideline 127 (2011)
Target Treatment BP 1

- Following diagnosis use clinic blood pressure to monitor response to antihypertensive treatment with lifestyle modifications and/or drugs.

- For people identified as having a ‘white-coat effect’ consider ABPM or HBPM as an adjunct to clinic blood pressure measurements to monitor response to treatment.

NICE Clinical Guideline 127 (2011)
Target Treatment BP 2

• When using ABPM or HBPM to monitor treatment response, aim for a target average blood pressure during the persons regular waking hours of:

• Below 135/85mmHg for people aged under 80
• Below 145/85mmHg for people aged 80 or over

NICE Clinical Guideline 127 (2011)
Normal ABPM

### Wake Period (07:00 - 23:00)

<table>
<thead>
<tr>
<th></th>
<th>MIN</th>
<th>AVG</th>
<th>MAX</th>
<th>STD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic</td>
<td>89 (07:38 Tue)</td>
<td>113</td>
<td>142 (12:01 Mon)</td>
<td>12.95 mmHg</td>
</tr>
<tr>
<td>Diastolic</td>
<td>51 (07:38 Tue)</td>
<td>76</td>
<td>98 (12:31 Mon)</td>
<td>11.28 mmHg</td>
</tr>
<tr>
<td>MAP</td>
<td>67</td>
<td>89</td>
<td>108</td>
<td>10.80 mmHg</td>
</tr>
<tr>
<td>Pulse Pressure</td>
<td>29</td>
<td>38</td>
<td>57</td>
<td>6.16 mmHg</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>57</td>
<td>69</td>
<td>83</td>
<td>7.27 bpm</td>
</tr>
</tbody>
</table>

- Percent of Systolic readings > 140mmHg: 3.7%
- Percent of Diastolic readings > 90mmHg: 11.1%

Number of Wake Period(s) readings: 27

### Sleep Period (23:00 - 07:00)

<table>
<thead>
<tr>
<th></th>
<th>MIN</th>
<th>AVG</th>
<th>MAX</th>
<th>STD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic</td>
<td>84 (02:11 Tue)</td>
<td>95</td>
<td>107 (03:08 Tue)</td>
<td>8.18 mmHg</td>
</tr>
<tr>
<td>Diastolic</td>
<td>48 (01:08 Tue)</td>
<td>59</td>
<td>70 (23:10 Mon)</td>
<td>7.65 mmHg</td>
</tr>
<tr>
<td>MAP</td>
<td>59</td>
<td>72</td>
<td>81</td>
<td>8.18 mmHg</td>
</tr>
<tr>
<td>Pulse Pressure</td>
<td>32</td>
<td>36</td>
<td>43</td>
<td>3.58 mmHg</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>53</td>
<td>66</td>
<td>82</td>
<td>8.61 bpm</td>
</tr>
</tbody>
</table>

- Percent of Systolic readings > 120mmHg: 0.0%
- Percent of Diastolic readings > 80mmHg: 0.0%

Number of Sleep Period(s) readings: 8
Stage 1 Hypertension

Wake Period(s) 07:00 - 23:00

<table>
<thead>
<tr>
<th></th>
<th>MIN</th>
<th>AVG</th>
<th>MAX</th>
<th>STD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic:</td>
<td>131</td>
<td>143</td>
<td>161</td>
<td>7.84</td>
</tr>
<tr>
<td>Diastolic:</td>
<td>67</td>
<td>91</td>
<td>98</td>
<td>7.32</td>
</tr>
<tr>
<td>MAP:</td>
<td>93</td>
<td>107</td>
<td>132</td>
<td>8.18</td>
</tr>
<tr>
<td>Pulse Pressure:</td>
<td>36</td>
<td>52</td>
<td>78</td>
<td>8.94</td>
</tr>
<tr>
<td>Heart Rate:</td>
<td>49</td>
<td>75</td>
<td>92</td>
<td>11.06</td>
</tr>
</tbody>
</table>

Percent of Systolic readings > 140mmHg: 62.5%
Percent of Diastolic readings > 90mmHg: 58.3%
Number of Wake Period(s) readings: 24
Stage 2 Hypertension

Wake Period(s) 07:00 - 23:00

<table>
<thead>
<tr>
<th></th>
<th>MIN</th>
<th>AVG</th>
<th>MAX</th>
<th>STD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic</td>
<td>142 (16:02 Wed)</td>
<td>166</td>
<td>181 (13:32 Thu)</td>
<td>11.19 mmHg</td>
</tr>
<tr>
<td>Diastolic</td>
<td>92 (15:02 Wed)</td>
<td>106</td>
<td>131 (21:35 Wed)</td>
<td>7.60 mmHg</td>
</tr>
<tr>
<td>MAP</td>
<td>108</td>
<td>114</td>
<td>147</td>
<td>10.38 mmHg</td>
</tr>
<tr>
<td>Pulse Pressure</td>
<td>40</td>
<td>60</td>
<td>77</td>
<td>9.53 mmHg</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>79</td>
<td>88</td>
<td>97</td>
<td>4.51 bpm</td>
</tr>
</tbody>
</table>

Percent of Systolic readings > 140mmHg: 100.0%
Percent of Diastolic readings > 90mmHg: 100.0%
Number of Wake Period(s) readings: 34

Sleep Period(s) 23:00 - 07:00

<table>
<thead>
<tr>
<th></th>
<th>MIN</th>
<th>AVG</th>
<th>MAX</th>
<th>STD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic</td>
<td>146 (00:02 Thu)</td>
<td>166</td>
<td>188 (23:02 Wed)</td>
<td>14.88 mmHg</td>
</tr>
<tr>
<td>Diastolic</td>
<td>86 (00:02 Thu)</td>
<td>97</td>
<td>114 (23:02 Wed)</td>
<td>10.43 mmHg</td>
</tr>
<tr>
<td>MAP</td>
<td>106</td>
<td>122</td>
<td>143</td>
<td>13.33 mmHg</td>
</tr>
<tr>
<td>Pulse Pressure</td>
<td>60</td>
<td>69</td>
<td>78</td>
<td>6.15 mmHg</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>86</td>
<td>89</td>
<td>93</td>
<td>2.76 bpm</td>
</tr>
</tbody>
</table>

Percent of Systolic readings > 120mmHg: 100.0%
Percent of Diastolic readings > 80mmHg: 100.0%
Number of Sleep Period(s) readings: 9
WCE & Stage 1 Hypertension

Wake Period(s) 07:00 - 23:00

<table>
<thead>
<tr>
<th>Parameter</th>
<th>MIN</th>
<th>AVG</th>
<th>MAX</th>
<th>STD</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic</td>
<td>104 (18:09 Mon)</td>
<td>137</td>
<td>191 (11:11 Mon)</td>
<td>19.78 mmHg</td>
<td></td>
</tr>
<tr>
<td>Diastolic</td>
<td>64 (18:09 Mon)</td>
<td>84</td>
<td>104 (12:09 Mon)</td>
<td>11.05 mmHg</td>
<td></td>
</tr>
<tr>
<td>MAP</td>
<td>79</td>
<td>102</td>
<td>134</td>
<td>13.82 mmHg</td>
<td></td>
</tr>
<tr>
<td>Pulse Pressure</td>
<td>36</td>
<td>52</td>
<td>92</td>
<td>12.09 mmHg</td>
<td></td>
</tr>
<tr>
<td>Heart Rate</td>
<td>76</td>
<td>87</td>
<td>108</td>
<td>7.49 bpm</td>
<td></td>
</tr>
</tbody>
</table>

Percent of Systolic readings > 140mmHg: 37.5%
Percent of Diastolic readings > 90mmHg: 28.1%

Reading(s) Time
31.7 %
24.6 %

Number of Wake Period(s) readings: 32

Sleep Period(s) 23:00 - 07:00

<table>
<thead>
<tr>
<th>Parameter</th>
<th>MIN</th>
<th>AVG</th>
<th>MAX</th>
<th>STD</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic</td>
<td>99 (00:09 Tue)</td>
<td>117</td>
<td>142 (05:09 Tue)</td>
<td>12.31 mmHg</td>
<td></td>
</tr>
<tr>
<td>Diastolic</td>
<td>63 (00:09 Tue)</td>
<td>72</td>
<td>77 (01:09 Tue)</td>
<td>4.78 mmHg</td>
<td></td>
</tr>
<tr>
<td>MAP</td>
<td>77</td>
<td>87</td>
<td>95</td>
<td>5.77 mmHg</td>
<td></td>
</tr>
<tr>
<td>Pulse Pressure</td>
<td>36</td>
<td>46</td>
<td>71</td>
<td>11.48 mmHg</td>
<td></td>
</tr>
<tr>
<td>Heart Rate</td>
<td>70</td>
<td>78</td>
<td>85</td>
<td>4.28 bpm</td>
<td></td>
</tr>
</tbody>
</table>

Percent of Systolic readings > 120mmHg: 25.0%
Percent of Diastolic readings > 80mmHg: 0.0%

Reading(s) Time
28.6 %
0.0 %

Number of Sleep Period(s) readings: 8
Web Resources

- [www.bhsoc.org/resources/abpm](http://www.bhsoc.org/resources/abpm)
- [www.bloodpressureuk.org](http://www.bloodpressureuk.org)
- [http://guidance.nice.org.uk/CG127](http://guidance.nice.org.uk/CG127)
- [www.mhra.gov.uk/Publications/Safetyguidance/Devic eBulletins/CON2024245](http://www.mhra.gov.uk/Publications/Safetyguidance/Devic eBulletins/CON2024245)
I would like to acknowledge the contributions from Jill Bunker, Naomi Stetson and Jamie Coleman in this presentation.
Any Questions?