Importance of Ambulatory Blood Pressure Monitoring in Adolescents

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24-hour ABPM in adolescents

- Ambulatory BP monitoring has become a useful tool in the study of BP in children and adolescents.
- Ambulatory BP monitoring is now increasingly recognized as being indispensable to the diagnosis and management of hypertension.
- Advantages and limitations need to be recognized at the time of using in research and clinical setting.
- Unmet needs challenge the future.
Ambulatory BP monitoring in adolescents

- Development and Fundamentals
- Prognostic value of 24-hour ABPM
- Recommendations for Using 24-hour ABPM
- Unmet needs in ABPM
Ambulatory BP monitoring in adolescents

- Development and Fundamentals
- Prognostic value of 24-hour ABPM
- Recommendations for Using 24-hour ABPM
- Unmet needs in ABPM
Starting point: The San Francisco experience

Office, ambulatory BPs and severity of organ damage

Semiautomatic patient-activate portable BP recorder

Sokolow M et al. Circulation 1966;34:279-298
Starting point:
The San Francisco experience

Semiautomatic patient-activate portable BP recorder in 1076 hypertensives

Cumulative incidence of CV events

Systolic
- $\geq 10\text{ mm Hg} > \text{RE } n=284$
- $\geq 10\text{ mm Hg} < \text{RE } n=281$

$P = .00005$

Mortality

Systolic
- $\geq 10\text{ mm Hg} > \text{RE } n=284$
- $\geq 10\text{ mm Hg} < \text{RE } n=281$

$P = .003$

Sokolow M, Perloff D et al. JAMA 1983;249:2792-2798
Technical and methodological developments

- **BP measurement:** oscillometric, auscultatory, both
- **Precision:** monitor internal algorithms, validation protocols (overall, subgroups)
- **Confortability:** size, noise
- **Additional measurements:** ECG, AASI, Central BP
ABPM basics were established from the beginning

- **Multiple** measurements improve reproducibility

- BP measurements **out-of-office** in normal living conditions reduce “alarm” reaction

- BP during **sleep** are measured

- Relation with **TOD** and **prognosis** give credibility

- **Discrepancies** in BP status between office and out-of-office BP measurements refine risk assessment
**ABPM basics were established from the beginning: Discrepancies**

<table>
<thead>
<tr>
<th>Clinic Pressure</th>
<th>95(^{th}) Percentile</th>
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<tbody>
<tr>
<td>White Coat HTN</td>
<td>Sustained HTN</td>
</tr>
<tr>
<td>False (White-coat) resistant HTN</td>
<td>Sustained uncontrolled HTN</td>
</tr>
<tr>
<td>True Normotension</td>
<td>Masked HTN</td>
</tr>
<tr>
<td>Sustained BP control</td>
<td>Mask (uncontrolled) resistant HTN</td>
</tr>
</tbody>
</table>
Additional issues on BP values from ABPM

- **Differences** between office and ambulatory BP values
- **Distribution** of the BP values
- **Reproducibility** of the BP-derived parameters
- Best valuable parameter?
- Reference values
Systolic BP values in office and Daytime ABP

Lurbe (data on file)
Systolic BP values in office and 24-hour ABP

![Scatter plot showing correlation between office SBP and 24-hour SBP](chart.png)

Lurbe (data on file)
Pulse Pressure values in office and 24-hour ABP: The relevance of distribution (SD)

*Office PP (mmHg)*

*24-hour Ambulatory PP (mmHg)*

*Lurbe (data on file)*
Temptation to overanalyze data: Multiple potential parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Time</th>
<th>Reproducibility</th>
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<tr>
<td>Average</td>
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<td>++++</td>
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<tr>
<td>Daytime</td>
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<tr>
<td>Nighttime</td>
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<tr>
<td>Pulse pressure</td>
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<td>Variability</td>
<td>Day-night ratio</td>
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<td>SD</td>
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<td>Morning surge</td>
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<td>+</td>
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<tr>
<td>“Load”</td>
<td>24-hour / periods</td>
<td>?</td>
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Key issue for clinical utility
Prognostic value of ABPM parameters

- **Nighttime BP** stronger predictor than daytime BP with **little additional information** from
  - Night / day BP ratio
  - Dipping phenomenon (poor reproducibility)
  - Extreme dipping

- **Other parameters** such as BP variability / morning BP surge / BP load / arterial stiffness index
  - Added **predictive value not yet clear**
  - Should be regarded as experimental / not for routine use

*Mancia et al. 2013 ESH/ESC Guidelines J Hypertens 2013;31:1281–357*
**Reference values:** German Working Group on Pediatric Hypertension. Distribution of 24-h ambulatory blood pressure in children: normalized reference values and role of body dimensions.

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Ambulatory BP monitoring in adolescents

Development and Fundamentals

Prognostic value of 24-hour ABPM

Recommendations for Using 24-hour ABPM

Unmet needs in ABPM
Superiority of ABPM to office BP in the relationship with early organ damage

Early organ damage
- LV Mass index
- Prevalence of LV hypertrophy
- Carotid wall thickness
- Urinary albumin excretion

BP levels
- Normotension
- Hypertension
- "White-coat"
- "Masked"

Essential HTN
- Obesity

Renal diseases
- CKD
- ESRD
- Renal transplant

Diseases
- Aortic coartation
Baseline monitoring

Enrolled 592

WC-HT 7

NT 535

M-HT 45

S-HT 5

Lurbe et al. Hypertension 2005;45:493-498
Follow-up

Enrolled 592

WC-HT 7

NT 535

Followed-up 200

NT 190

M-HT 9*

Followed-up 34

NT 18

M-HT 13†

S-HT 3

M-HT 45

Followed-up 34

NT 18

M-HT 13†

S-HT 3

Follow-up

Lurbe et al. Hypertension 2005;45:493-498
Left ventricular mass index and the distribution of sex-specific percentiles in normotensive and masked hypertensive subjects

Lurbe et al. Hypertension 2005;45:493-498
Prognostic value of ABPM: The case of discrepancies

- LV Mass index
- Prevalence of LV hypertrophy
- Incident sustained HTN
Incident sustained hypertension in children and adolescents

Incident HTN rate

Normotension
0.52/100 subjects/year

Masked
7.96/100 subjects/year

Factors related to develop hypertension

234 subjects, average of follow-up 38 months

Adjusted by age, sex, family history, overweight

Prognostic value of ABPM: Follow-up studies with repeated monitorings

- Early nephropathy
- ESRD
Persistence of non-dipping pattern heralds the development of early diabetic nephropathy in normotensive Type 1 diabetes

Lurbe, Redon, Pascual et al. NEJM 2002;347:797-805
Ambulatory Blood-Pressure Monitoring as a Predictive Tool

Although some patients with type 1 diabetes mellitus have complications, such as diabetic nephropathy, many do not. Thus, a simple, noninvasive method of identifying those at highest — and lowest — risk for the development of complications would be invaluable.

Certain markers, such as microalbuminuria, which indicates the presence of very early renal disease, offer some promise. Yet if micro-

Normal and Abnormal Circadian Patterns of Blood Pressure. The normal pattern is characterized by a drop in blood pressure during the night and early morning, and the abnormal pattern by the absence of a nocturnal drop in pressure.

Julie R. Ingelfinger, M.D.
24-hour ABP targeted and renal outcomes in children with renal disease (ESCAPE trial)

24-hour ABP targeted and renal outcomes by renal disease (ESCAPE trial)

Ambulatory BP monitoring in adolescents

Development and Fundamentals

Prognostic value of 24-hour ABPM

Recommendations for Using 24-hour ABPM

Unmet needs in ABPM
2016 Guidelines: Recommendations for 24-hour ambulatory BP measurements

During the process of diagnosis

- Confirm hypertension before starting antihypertensive drug treatment in order to avoid treatment of white coat hypertension
- Target organ damage (LVH, microalbuminuria) and office BP normal (masked hypertension)
- Type 1 and Type 2 diabetes
- Chronic kidney disease
- Renal, liver or heart transplant
- Severe obesity with or without sleep-disordered breathing
- Hypertensive response during the treadmill test
- Discrepancy between office BP and home BP

2016 Guidelines: Recommendations for 24-hour ambulatory BP measurements

<table>
<thead>
<tr>
<th>During antihypertensive drug treatment</th>
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<tbody>
<tr>
<td>Evaluate for apparent drug-resistant hypertension</td>
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<tr>
<td>Assessment of BP control in children with target organ damage</td>
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<tr>
<td>Symptoms of hypotension</td>
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<table>
<thead>
<tr>
<th>Clinical trials</th>
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<tr>
<th>Other clinical conditions</th>
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<tbody>
<tr>
<td>Autonomic dysfunction</td>
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<tr>
<td>Suspicion of catecholamine-secreting tumours</td>
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# 2016 Guidelines: Home BP monitoring, methodological aspects and clinical indications for use

## Methodological Aspects

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
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</thead>
<tbody>
<tr>
<td>Measured daily on at least 3–4 days, preferably on 7 consecutive days in the mornings as well as in the evenings</td>
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<tr>
<td>Measured in a quiet room, with the subject in the seated position, back and arm supported, after 5 min of rest</td>
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<tr>
<td>Two measurements per occasion taken 1–2 min apart</td>
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<tr>
<td>Home BP is the average of these readings, with exclusion of the first monitoring day</td>
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</table>

## Clinical indications for use

<table>
<thead>
<tr>
<th>Indication</th>
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<tbody>
<tr>
<td>All patients receiving antihypertensive medication</td>
</tr>
<tr>
<td>Suspicion of white-coat hypertension</td>
</tr>
<tr>
<td>Conditions where strict blood pressure control is mandatory (high-risk patients)</td>
</tr>
<tr>
<td>Clinical trials</td>
</tr>
</tbody>
</table>

2016 Guidelines: Follow-up

**BLOOD PRESSURE MEASUREMENT**

- Depending on the underlying cause of HTN, periodic, probably life-long follow-up is advisable in the majority of children
- Regular **home BP monitoring** can greatly facilitate the management of HTN for better assessing of BP control
- In children with CKD or diabetes, regular **ABPM measurements at 6-12-month** intervals are recommended to rule out selective nocturnal HTN

Ambulatory BP monitoring in adolescents

Development and Fundamentals

Prognostic value of 24-hour ABPM

Recommendations for Using 24-hour ABPM

Unmet needs in ABPM
2016 Guidelines: Future research

• Develop accurate devices for oscillometric BP measurement.

• Obtain robust reference values for office, home and ambulatory BP based on a European pediatric population.

• Increase knowledge in the use of out-of-office BP measurements, 24-hour and home.

• Refine the clinical significance of white-coat, masked HTN.

• Obtain further insights about Central BP and Pulse Wave Velocity as markers of function of the vascular system.

• Unravel the significance of Isolated Systolic Hypertension and their management.

The unmet needs in ABPM and HBPM

No definition of hypertension using ABPM

No evidence for ABP goals during antihypertensive treatment

No evidence that ABPM-guided can obtain greater reductions in morbidity and mortality than clinic-guided therapy

Redon, Lurbe. Hypertension 2014;64:1169-1174
24-hour ABPM in adolescents: Take home messages

- Ambulatory BP monitoring has become a useful tool in the study of BP in children and adolescents.
- Ambulatory BP monitoring is now increasingly recognized as being indispensable to the diagnosis and management of hypertension.
- Advantages and limitations need to be recognized at the time of using in research and clinical setting.
- Unmet needs challenge the future.