How to measure blood pressure?
Introduction:

Limitation of in-office BP (OBPM)

- Poor accuracy and precision
- SNS response: white-coat effect
- Failure to capture daily activity effect
- Failure to monitor nighttime BP
- Inability to Dx white-coat Hypertension
- Inability to Dx masked Hypertension
OSCILLOMETRIC TECHNIQUE

Clinic Pressure

≥140/90

White Coat Hypertension

Sustained Hypertension

Sustained Normotension

Masked Hypertension

Ambulatory Pressure

≥135/85
Case Study: 62 y/o white obese male with type 2 DM

- **Dx:** **OBPM:** High-normal BP (130/85 mm Hg)

- Diabetes and hypertension: both predispose to the development of each other and to cardiovascular disease.

- How should we evaluate blood pressure in this man?

- When are we justified in starting antihypertensive Rx?

- How best to monitor the adequacy of treatment?
Automated office BP Measurements (AOBPM)

- Fully automated device, which takes multiple readings with subjects resting quietly alone

- BpTru device: initial test reading and then 5 readings at 1-minute intervals with subjects sitting quietly alone without conversation

- The device automatically computes the mean of the 5 readings. BP ≥135/85 = hypertension.

- HR: 1.66 (1.09-2.54) p=0.02 at SBP of 135-144

Myers MG, et al. Hypertension. 2015;66 (on line)
Call to Action on Use and Reimbursement for Home Blood Pressure Monitoring: Executive Summary: A Joint Scientific Statement From the American Heart Association, American Society of Hypertension, and Preventive Cardiovascular Nurses Association
Thomas G. Pickering, Nancy Houston Miller, Gbenga Ogedegbe, Lawrence R. Krakoff, Nancy T. Artinian and David Goff

Home BP (HBPM)

- Measure BP a.m. and p.m. daily x 7 days
- Discard 1st day’s BPs and average all the rest
- Treat HTN if average BP > 135/85
Self-Measurement of BP

- Provides information useful for:
  1. Evaluating white-coat/masked HTN
  2. Assessing response to antihypertensive Rx
  3. Improving adherence with therapy

- Home BP is more strongly related to target organ damage and has better prognostic accuracy than office BP.
How Does ABPM Work?

Monitor programmed to take BP measurements repeatedly over 24 hours

Patients go about normal activities

Report shows variation in BP over time

24-Hour Blood-Pressure Tracing in a Patient with Hypertension

Definitions

• Current consensus out-of-office HTN for both HBPM and ABPM:
  -- Daytime: ≥ 135/85 mm Hg
  -- 24-hour: ≥ 130/80 mm Hg
  -- Nighttime: ≥ 120/70 mm Hg

• Conventional sustained NTN and masked HTN in-office BP: <140/<90 mm Hg.
• Conventional sustained NTN out-of-office daytime BP <135/<85 mm Hg.
Superiority of ambulatory BP for predicting CV death


**Table:**

<table>
<thead>
<tr>
<th>Systolic BP, mm Hg</th>
<th>Adjusted 5-Y. Risk of CV Death (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>90</td>
<td>0.5</td>
</tr>
<tr>
<td>110</td>
<td>1.0</td>
</tr>
<tr>
<td>130</td>
<td>1.5</td>
</tr>
<tr>
<td>150</td>
<td>2.0</td>
</tr>
<tr>
<td>170</td>
<td>2.5</td>
</tr>
<tr>
<td>190</td>
<td>3.0</td>
</tr>
<tr>
<td>210</td>
<td>3.5</td>
</tr>
<tr>
<td>230</td>
<td>n=5,292</td>
</tr>
</tbody>
</table>

**Graph:**

- Conventional Office BP
- Daytime BP
- 24 h BP
- Nocturnal BP

White-Coat Effect verses White-Coat HTN

- **White-coat effect (WCE)** is rise of BP in a medical environment regardless of daytime ABPM or use of Rx.

- **White coat hypertension (WCH)** exists if office BP is high ($\geq 140/\geq 90$) and awake daytime ABPM is $<135/85$ mm Hg.

- Incidence of **WCH** increases with aging and the size of the **WCE** increases with aging.

- **WCH** cannot reliably be diagnosed by routine office or clinic evaluation.
International Database of Ambulatory BP in relation to Cardiovascular Outcome

IDACO
IDACO Populations for 24-h ABPM

Countries: Denmark, Sweden, Russia, Ukraine, China, Poland, Czech Republic, Italy, Ireland, Japan, Belgium, Uruguay.
Significance of White-Coat Hypertension in Older Persons With Isolated Systolic Hypertension: A Meta-Analysis Using the International Database on Ambulatory Blood Pressure Monitoring in Relation to Cardiovascular Outcomes Population

Stanley S. Franklin, Lutgarde Thijs, Tine W. Hansen, Yan Li, José Boggia, Masahiro Kikuya, Kristina Björklund-Bodegård, Takayoshi Ohkubo, Jørgen Jeppesen, Christian Torp-Pedersen, Eamon Dolan, Tatiana Kuznetsova, Katarzyna Stolarz-Skrzypek, Valérie Tikhonoff, Sofia Malyutina, Edoardo Casiglia, Yuri Nikitin, Lars Lind, Edgardo Sandoya, Kalina Kawecka-Jaszcz, Yutaka Imai, Jiguang Wang, Hans Ibsen, Eoin O'Brien and Jan A. Staessen
# 1168 persons with untreated ISH (age: 64 yrs. total=6439)

<table>
<thead>
<tr>
<th>Clinic Pressure</th>
<th>White Coat Hypertension</th>
<th>Sustained Hypertension</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥140/90</td>
<td>(334=28.5% ISH)</td>
<td>(314=26.9% ISH)</td>
</tr>
<tr>
<td></td>
<td>(WCE=22.2 mm Hg)</td>
<td>(SBP=152 mmHg)</td>
</tr>
<tr>
<td></td>
<td>(SBP=148 mmHg)</td>
<td></td>
</tr>
<tr>
<td>Sustained Normotension</td>
<td>5271=81.9% Tot</td>
<td>Masked Hypertension</td>
</tr>
<tr>
<td></td>
<td>(SBP=116 mmHg)</td>
<td>(520=44.5% ISH)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(126 mm Hg)</td>
</tr>
</tbody>
</table>

Summary:

• The exclusive use of conventional office BP would result in failure to recognize white-coat and masked HTN in 854/1168 (73%), almost 3 of 4 persons with untreated ISH.

• This would result in the overtreatment of white-coat HTN and underdiagnosis and undertreatment of masked HTN.
Factors associated with high risk of masked hypertension

- Failure to achieve sleep of 6 or more hours
- Sleep apnea
- Working/living in very high stress environment
- Smoking
- Heavy or binge drinking
- Periotic high salt load daily, especially elderly
- CKD (eGFR<60 mL/min/1.73 m²)
- Obesity, metabolic syndrome, diabetes
Masked Hypertension in Diabetes Mellitus: Treatment Implications for Clinical Practice
Stanley S. Franklin, Lutgarde Thijs, Yan Li, Tine W. Hansen, José Boggia, Yanping Liu, Kei Asayama, Kristina Björklund-Bodegård, Takayoshi Ohkubo, Jørgen Jeppesen, Christian Torp-Pedersen, Eamon Dolan, Tatiana Kuznetsova, Katarzyna Stolarz-Skrzypiec, Valérie Tikhonoff, Sofia Malyutina, Edoardo Casiglia, Yuri Nikitin, Lars Lind, Edgardo Sandoya, Kalina Kawecka-Jaszcz, Jan Filipovský, Yutaka Imai, Jiguang Wang, Hans Ibsen, Eoin O'Brien and Jan A. Staessen

on behalf of the International Database on Ambulatory blood pressure in relation to Cardiovascular Outcomes (IDACO) Investigators

Hypertension. 2013;61:964-971; originally published online March 11, 2013;
doi: 10.1161/HYPERTENSIONAHA.111.00289
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Prevalence of masked HTN is greater in the diabetic than non-diabetic regardless of Rx status

<table>
<thead>
<tr>
<th>Rx status</th>
<th>% MH Non-DM</th>
<th>%MH DM</th>
<th>OR (un-adj.)</th>
<th>OR (Part Adj.)</th>
<th>OR (Full Adj.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Un-Rx</td>
<td>18.8% (1031/5486)</td>
<td>29.3% (67/229)</td>
<td>1.79 (1.33,2.40)</td>
<td>1.46 (1.08,1.98)</td>
<td>1.35 (0.98,1.86)</td>
</tr>
<tr>
<td>Rx</td>
<td>30.5% (192/630)</td>
<td>42.5% (37/87)</td>
<td>1.69 (1.07,2.67)</td>
<td>1.59 (1.00,2.52)</td>
<td>1.59 (0.98,2.58)</td>
</tr>
</tbody>
</table>

Part Adj., for sex and age
Full Adj., for sex, age, conventional SBP, Hx CV complications, current smoking, Alcohol intake, body mass index, total cholesterol, and intake of antihypertensive Drugs (only when Rx and un-Rx subjects are combined)
Untreated Masked hypertension with target organ damage presenting as pre-HTN in DM2 patients

- Presence of masked HTN (MH) in DM2 patients = 30% (41/135 office NTN)
- Office MH: BP = 128/76 mm Hg (IDACO: 129/76)
- Office NTN: BP = 123/77 mm Hg (IDACO: 122/72)
- Office MH vs. NTN: macroalbuminuria+ (p=0.001)
- Office MH vs. NTN: LVH+ (p=0.015)

~ 1/3 of DM2 patients misclassified as normotensive!

TOD occurs before MH transitions to sustained HTN

Leitao, CB., Diabetic Care 2007;30:1255-1260
Frequency of Masked Uncontrolled HTN in CKD

- Clinic SBP 130-139 mm Hg (high-normal) MUCH present in 2 of 3
- Clinic SBP 120-129 mm Hg (normal) MUCH present in 1 of 3
- Clinic SBP 110-119 mm Hg (optimal) MUCH present in 1 of 6

Agarwal R, et al. JASN. 2015 (on line)
Definitions for HTN Rx

• The prevalence of masked HTN focuses on ‘treatment naïve’ patients prior to the diagnosis of HTN.

• In patients with treated HTN, the presence of residual masked HTN is called “masked uncontrolled HTN” (MUCH).

• By definition, MUCH implies suboptimal control by ABPM, even when controlled to in-office/clinic BP target.
High percentage of MUCH using office BP for treatment guide.

- Almost a third (31%) of patients with well controlled office BP on antihypertensive Rx had “masked uncontrolled hypertension (MUCH).”

- MUCH Pts. characterized as males. obese, long duration of HTN, older Pts. smokers, diabetics, and with dyslipidemia; thus, high-risk for CVD

- Resistant HTN in MUCH Patients: frequently, because of failure to control nighttime HTN.

Banegas JR, et al., European Heart J. 2014; (on line Feb 3)
50 y/o African American man with Stage 3 CKD, LVH, and on-treatment office SBP 132

Masked HTN
- CKD 40%
  (Bangash & Agarwal, 2009)
- Diabetes 29%
  (Franklin et al., 2013)
- NH blacks 34%
  (Diaz et al., 2014)
Frail 69 y/o lady with on-treatment office SBP 160

- ISH & white coat HTN
- Postprandial & orthostatic hypotension
Practical Approach to Management in the Elderly Hypertensive patient

• Use out-of-office home BP monitoring (HBPM) to diagnose white-coat and masked hypertension.
• Multiple readings before make diagnosis
• Confirm with 24-hour ABPM
• Start low and go slow with therapy.
• Monitor both sitting and standing BP
• Inquire as to symptoms of orthostasis.
• If significant orthostasis, standing BP sets limits.
• Special caution in the frail elderly.
Indications for BP Screening by ABPM

- Hypertension by office measurement
- Pre-hypertension by office measurement
- Middle-aged and older, esp. women
- African Americans: young and old
- Overweight/obese/metabolic syndr. /DM
- Unexplained LVH
- History of cardiovascular events

Summary: Dx and Rx Strategy for Masked HTN and MUCH

- Automated office BP superior to conventional office, but both inferior to out-of-office BP recordings.
- HBPM useful for titration of medication.
- HBPM inferior to ABPM because latter records BP during daily activity, while HBPM readings always are taken at rest.
- Consequently, Dx of masked HTN and MUCH should be confirmed by ABPM!
Case Study: 62 y/o white obese male with type 2 DM

1. Dx: **OBPM:** High-normal BP (130/85 mm Hg)
2. Dx: **1st ABPM:** Masked HTN ↑ daytime, nighttime, 24-hr.
3. Dx: **Echo:** LVH; **Ualb/creatinine:** Macro-albuminuria
4. Rx: **ARB + CCB:** titration by **HBPM**
5. Dx: **2nd ABPM:** persistent nighttime HTN “MUCH”
6. Rx: add diuretic: titration by **HBPM**
7. Dx: **3rd ABPM:** normal nighttime BP
SPRINT STUDY

- Randomized 9361 participants age ≥50 y
- 2648 with CKD: eGFR <60mL/min/1.73
- 2636 ≥75 years of age: the elderly
- 1877 with Hx of CVD
- SPRINT MIND MRI participants: dementia
- Expect results by Fall of 2017: ended 9/15
- Target SBP: 120 superior to 140 mm Hg
  - CHD, HF, stroke by 1/3; death by ¼
- Why? Omron HEM-907: 3 readings AOBP
Individuals who are normotensive at age 55 have a 90% lifetime risk of developing “hypertension”

Value of ABPM:

- ABPM can save money!
- The extra cost of providing this technique is more than offset by cost saving from:
  1. Eliminating unnecessary treatment for patients with white coat HTN.
  2. Correctly treating masked HTN that would ordinarily be missed with resulting potentially preventable CVD events with Rx.
  3. Use a pharmacy rather than a hospital.
Masked Hypertension: “Resistant” to Diagnosis and Treatment

• Hypertensive Cardiovascular Disease: #1 cause of mortality worldwide.

• Masked HTN and Masked uncontrolled HTN: 2 impediments to reducing HTN CVD worldwide!

• And White Coat HTN, especially in elderly, is the main cause of unnecessary Rx!