Assessing Blood Pressure for Clinical Research: Pearls & Pitfalls

Anthony J. Viera, MD, MPH, FAHA
Department of Family Medicine
Hypertension Research Program
UNC School of Medicine

Objectives

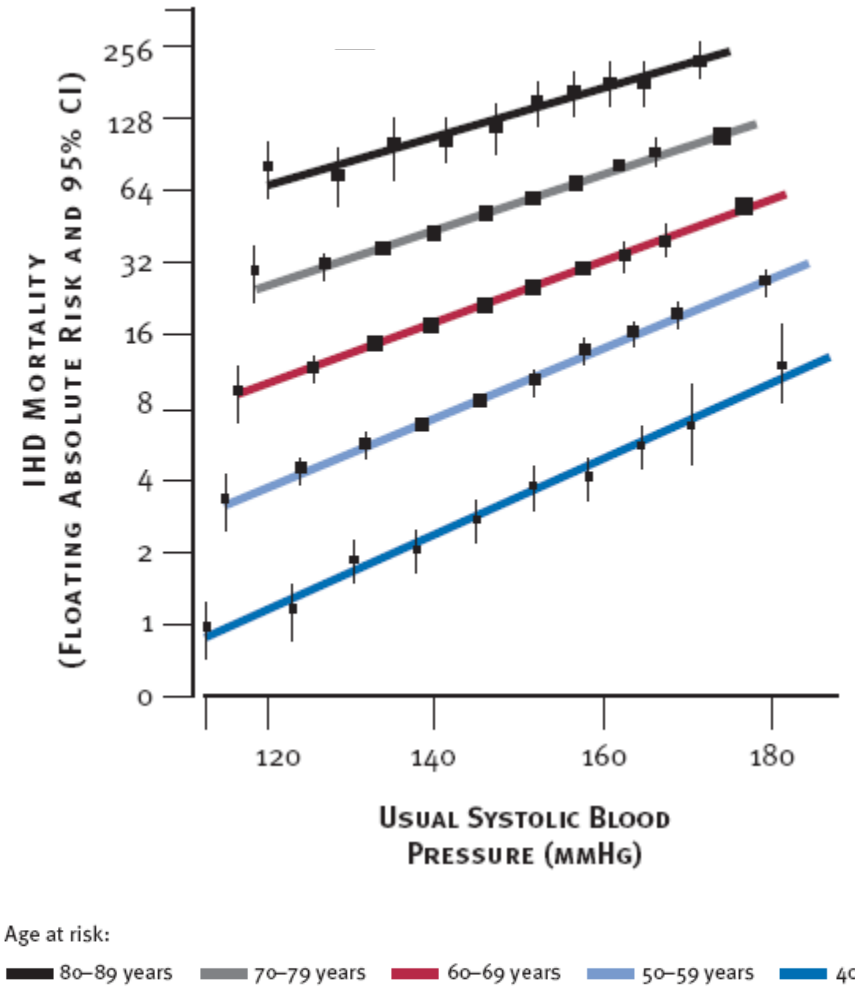
- Review limitations of office (and research visit) measurements of BP
- Discuss the role of ABPM as the gold standard for accurate assessment & use of home BP monitoring as an alternative
- Describe pros & cons of each method

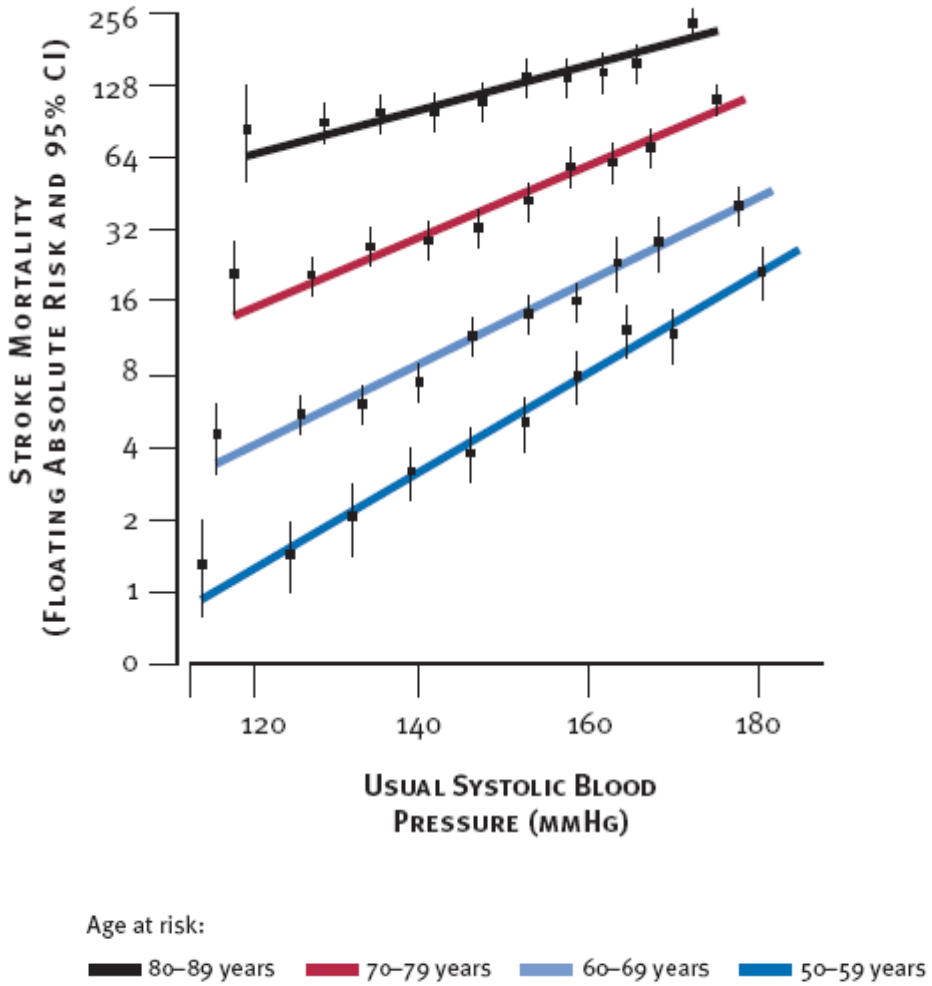
High blood pressure

- 1 out of 3 adults (74 million) in US
- 90% lifetime risk of developing hypertension
- Responsible for 35% of all myocardial infarctions and strokes and 50% of congestive heart failure
- Contributes to peripheral vascular disease, end-stage renal disease, aortic aneurysm, retinopathy

Go AS, et al; American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Heart and stroke statistics 2014 update. A report from the American Heart Association. Circulation. 2014;129:e28-e292.

Relationship of BP to events





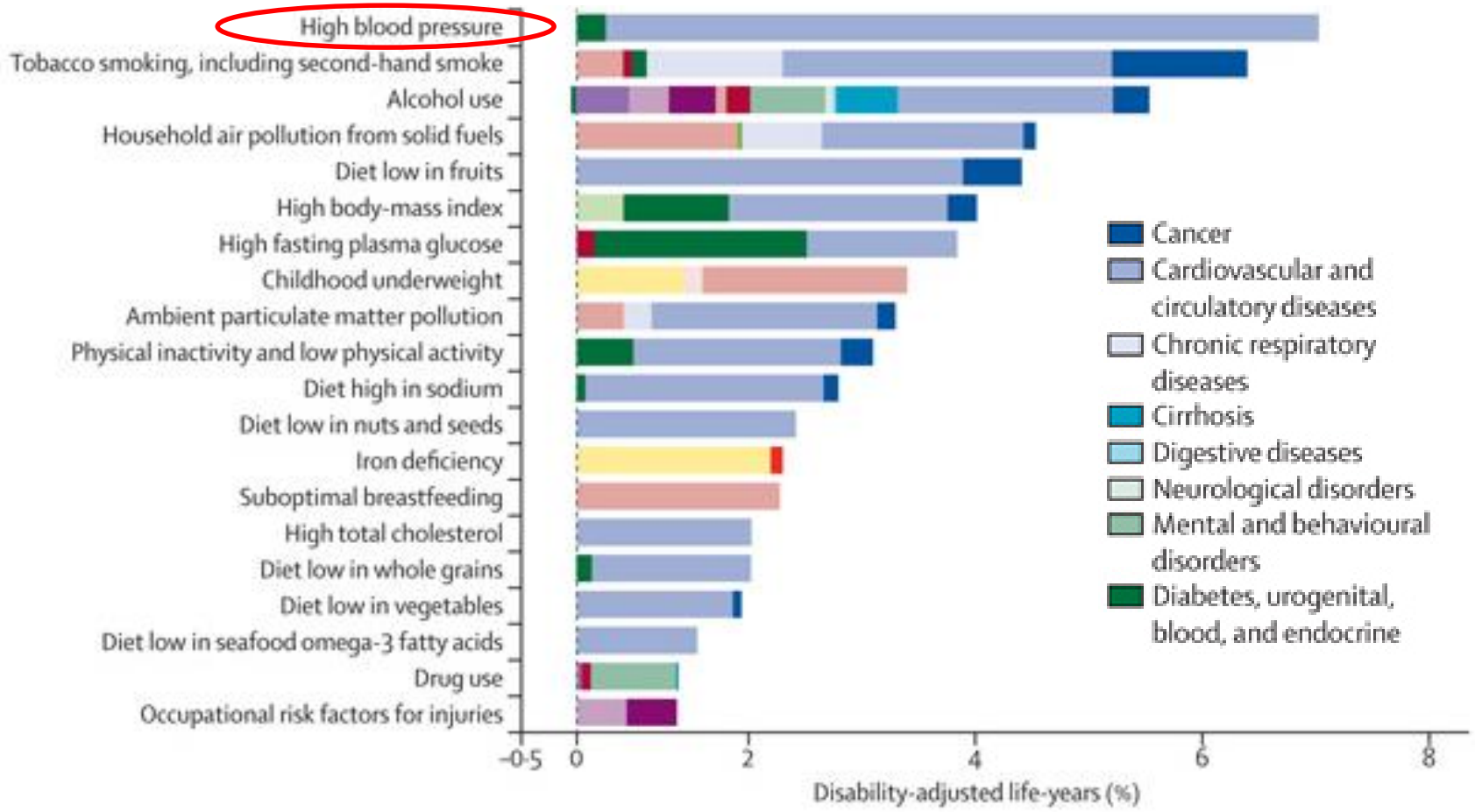
Lewington S, et al. Age-specific relevance of usual blood pressure to vascular mortality: A meta-analysis of individual data for one million adults in 61 prospective studies. (The Lancet 2002; 360:1903–13).

Treatment of high BP

- Reduces risk of strokes by 40%
- Reduces risk of MI by 25%
- Reduces risk of CHF by 50%

Chobanian AV, Bakris GL, Black HR, et al. JAMA. 2003; 289: 2560-72.

Burden of disease in 2010, for men and women combined



Lim et al. Lancet 2012;380:2224-2260

BP is commonly included in clinical research studies

- Studies of cardiovascular disease
- Studies involving kidneys, brain, heart,… just about any organ
- Drug studies, even drugs not for lowering BP (so-called cardiovascular effects of non-cardiovascular drugs)
- And it’s relatively “easy” to measure

Office BP

- BP measurement is basis for diagnosis (the most common diagnosis in adult primary care)
- Accurate measurement of BP is challenging, especially in busy office practices
- Mercury no longer used
- Oscillometric devices predominate

Limitations of Office BP

- Poor quality control due to technique
  - Wrong cuff size
  - Improper patient position (e.g. feet not on floor, arm not at heart level)
  - Failure to allow 5 minutes rest
  - If manual sphygmomanometer used
    - Letting air out of cuff too rapidly
    - Digit bias (rounding to nearest 5 or 10 mmHg)
    - Other observer biases

Why is a research visit BP better?

- Correct technique is followed
- Protocol is standardized
- Participant not there for a “doctor visit”

- Research BP measurements tend to be lower than clinic (office) BP measurements

Limitation of clinic and research visit BP

Even when done correctly…

- Limited reliability due to the small number of readings
- Substantial variability from inherent and external factors

Misclassification

- Can overestimate usual BP
  - White-coat hypertension may be misclassified as (sustained) hypertension
- Overdiagnosis → overtreatment → harms

Lesser known…

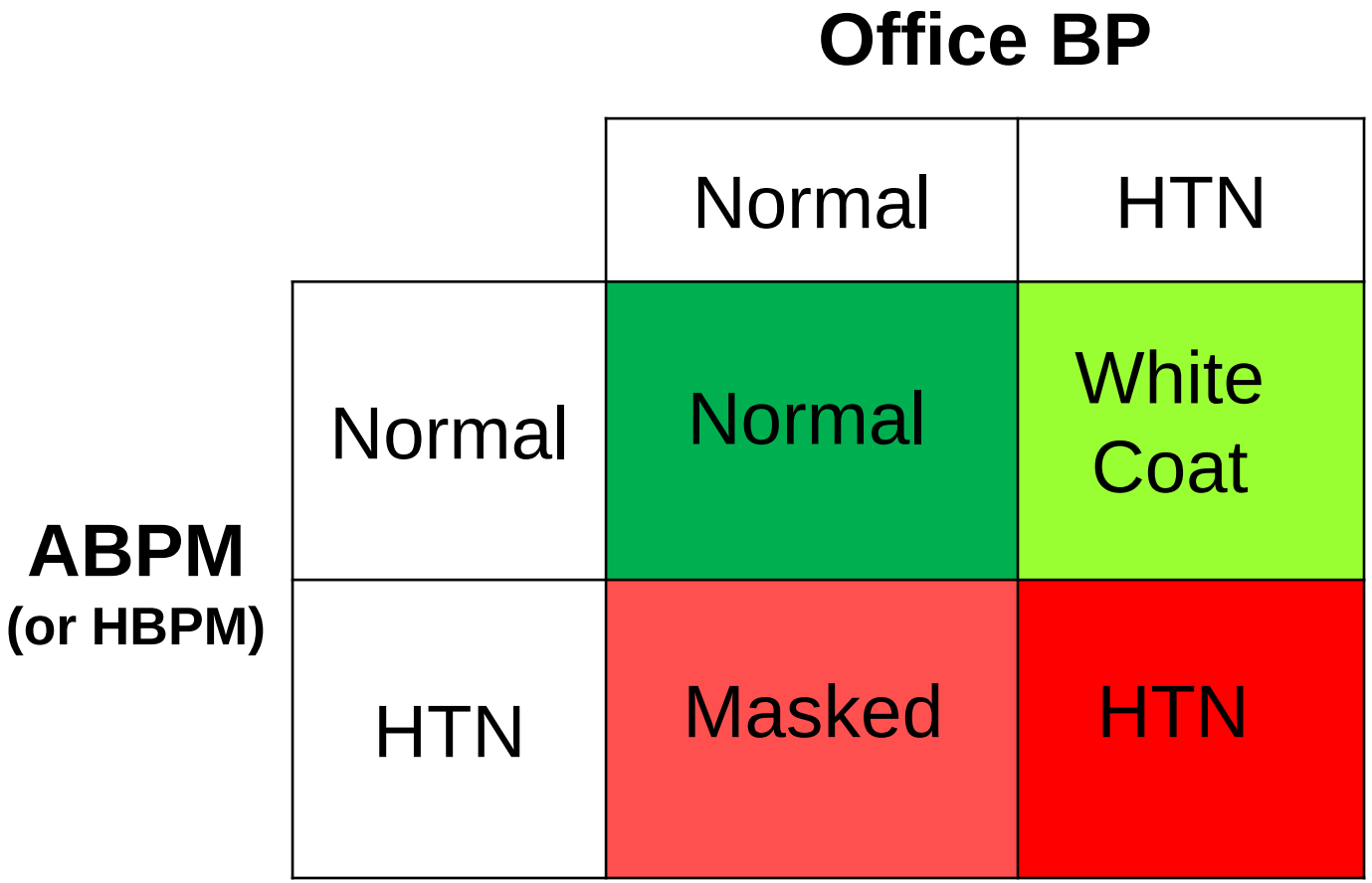
But possibly more important

- Office reading may underestimate usual BP
- Person at increased cardiovascular risk not offered treatment

Alternatives to clinic or research visit BP

- Ambulatory BP monitoring
- Home BP monitoring
- ~~Pharmacy kiosk monitoring~~

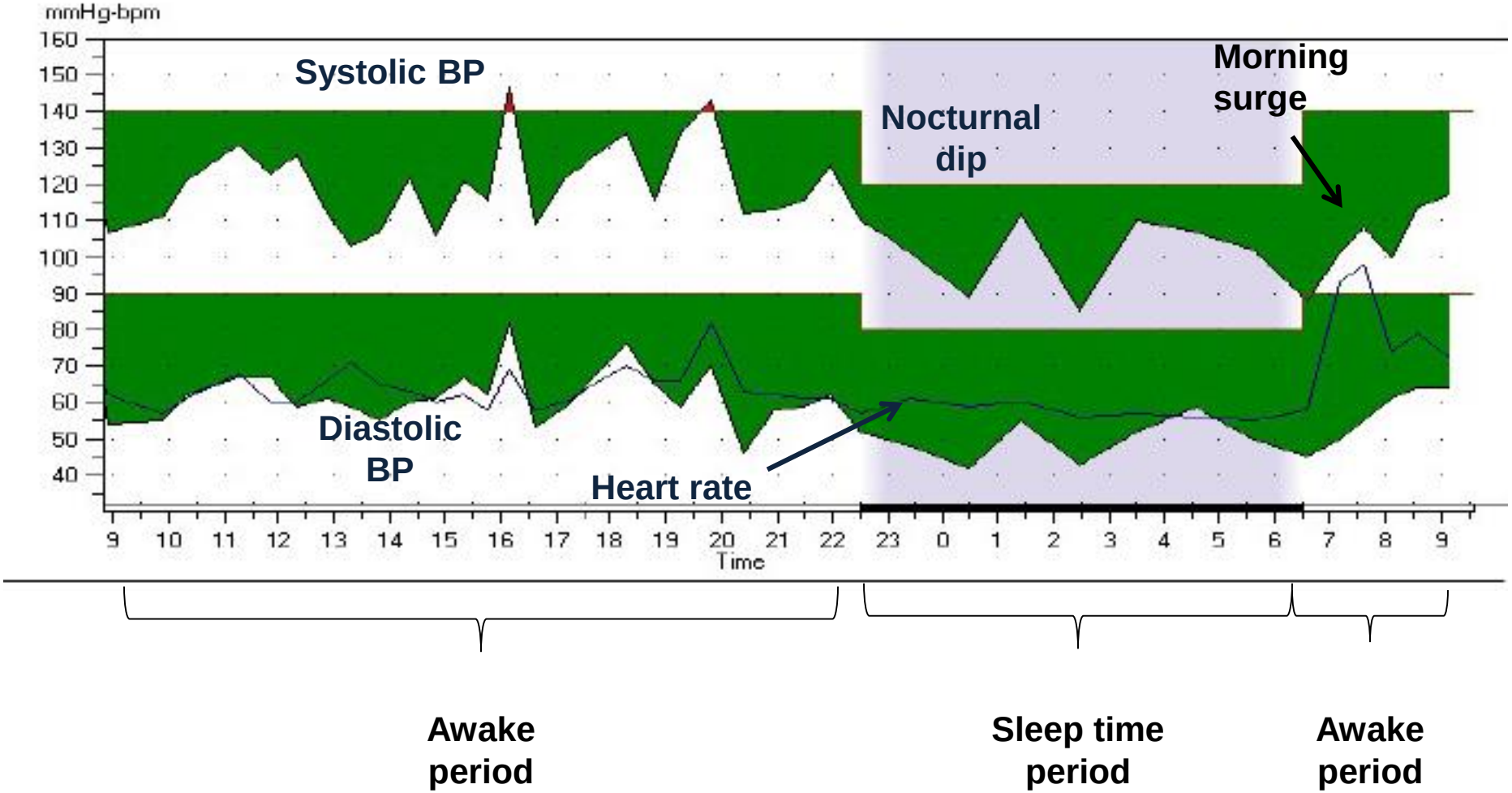
Pairing office & out-of-office



Ambulatory BP monitoring

- Multiple readings over the course of 24 hours
- Superior to office BP in predicting outcomes
- Considered to be the noninvasive gold standard

Normal ABPM


mmHg-bpm
160
150
140
130
120
110
100
90
80
70
60
50
40
Systolic BP
Nocturnal dip
Morning surge
Diastolic BP
Heart rate
9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 0 1 2 3 4 5 6 7 8 9
Time
Awake period
Sleep time period
Awake period

Definitions

- “Cut-offs” for ABPM:

	Cut-off (mmHg)
Awake average	135/85
Nighttime (sleep) average	120/70
24-hour average	130/80

BP dip and BP load

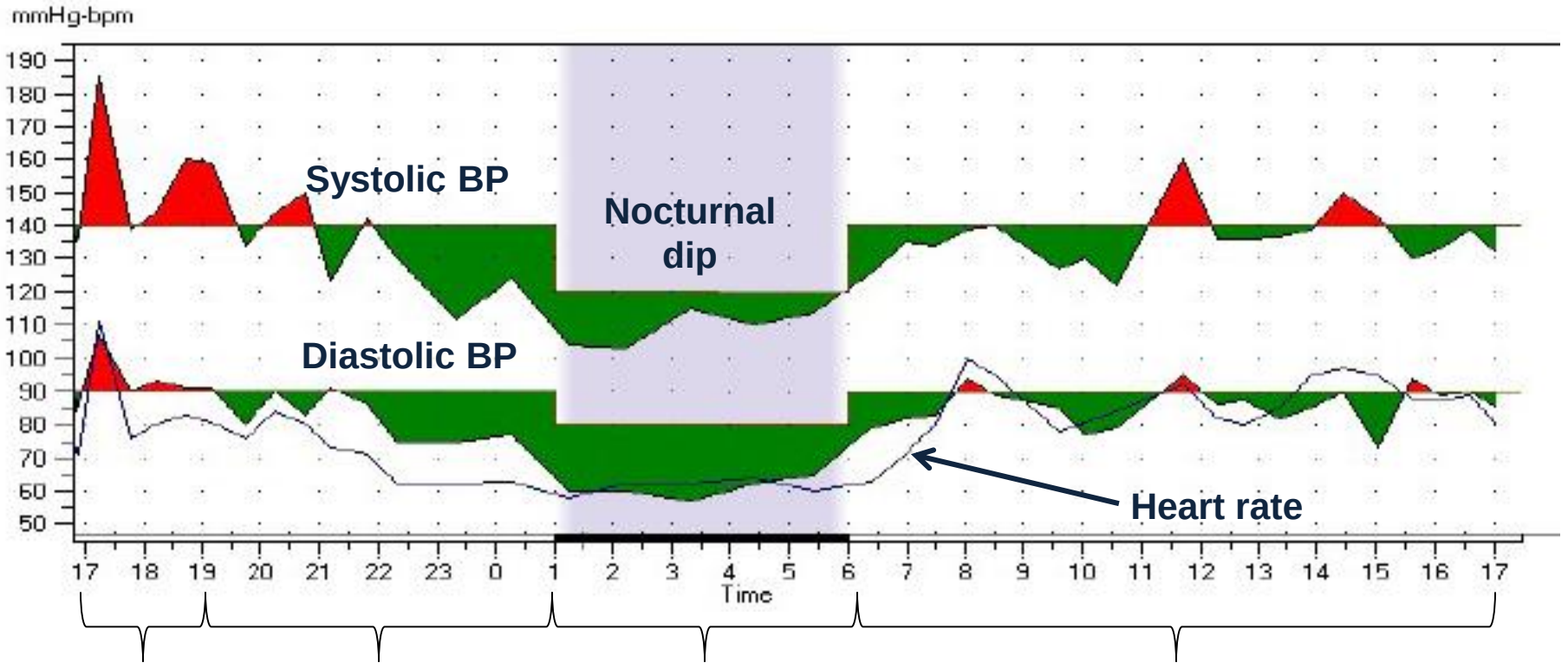
- Nocturnal dip
  - Normal is 10% to 20%
  - <10% is nondipper; >20% extreme dipper
  - Some are risers (reverse dippers)
- BP load
  - % of BP readings above threshold
  - <25% considered normal
  - >50% abnormal or higher risk

ABPM report

From 40+ BP measurements

- Mean overall BP
- Mean awake BP
- Mean sleep BP
- Nocturnal dip
- BP load

Graph of ABPM data



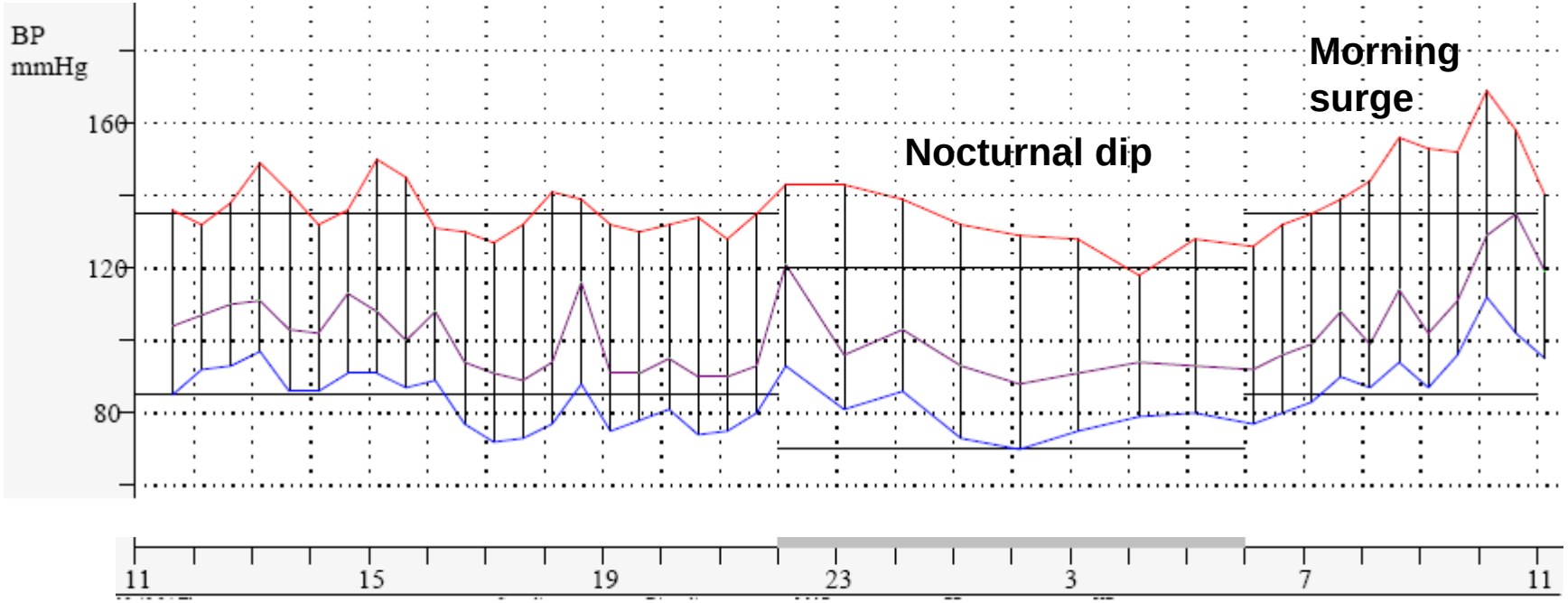
“White coat” period

Awake period

Sleep time period

Awake period

Graph of ABPM data

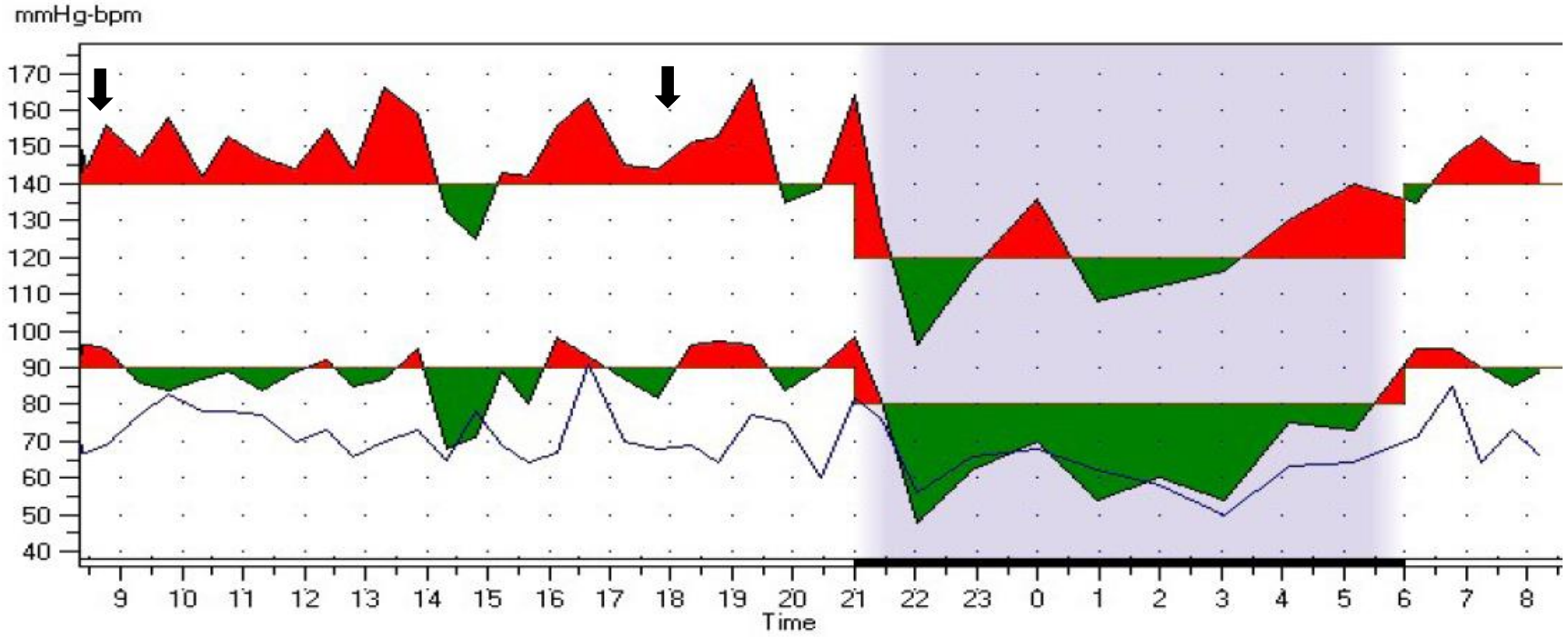


#		Time	Sys	Dia	MAP	PP	HR
1	M	11:38 Wed	136	85	104	51	67
3		12:08	132	92	107	40	98
4		12:38	138	93	110	45	112
5		13:08	149	97	111	52	90
6		13:38	141	86	103	55	75
7		14:08	132	86	102	46	72
8		14:38	136	91	113	45	86
9		15:08	150	91	108	59	84
10		15:38	145	87	100	58	75
11		16:08	131	89	108	42	85
12		16:38	130	77	94	53	68
13		17:08	127	72	91	55	57
14		17:38	132	73	89	59	62
15		18:08	141	77	94	64	63
16		18:38	139	88	116	51	103
17		19:08	132	75	91	57	59
18		19:38	130	78	91	52	63
19		20:08	132	81	95	51	56
20		20:38	134	74	90	60	62
21		21:08	128	75	90	53	61
22		21:38	135	80	93	55	66
23		22:08	143	93	121	50	100
24		23:08	143	81	96	62	72
25		00:08 Thu	139	86	103	53	70
26		01:08	132	73	93	59	52
27		02:08	129	70	88	59	57
28		03:08	128	75	91	53	54
30	R	04:11	118	79	94	39	52

ABPM Report

- Quality
  - 98% readings overall
- Mean overall: 138/85 mmHg
- Mean awake: 139/86 mmHg
- Mean sleep : 133/80 mmHg
- Nocturnal dip: 4%
- SBP load: 60%

Graph of ABPM data



ABPM Report

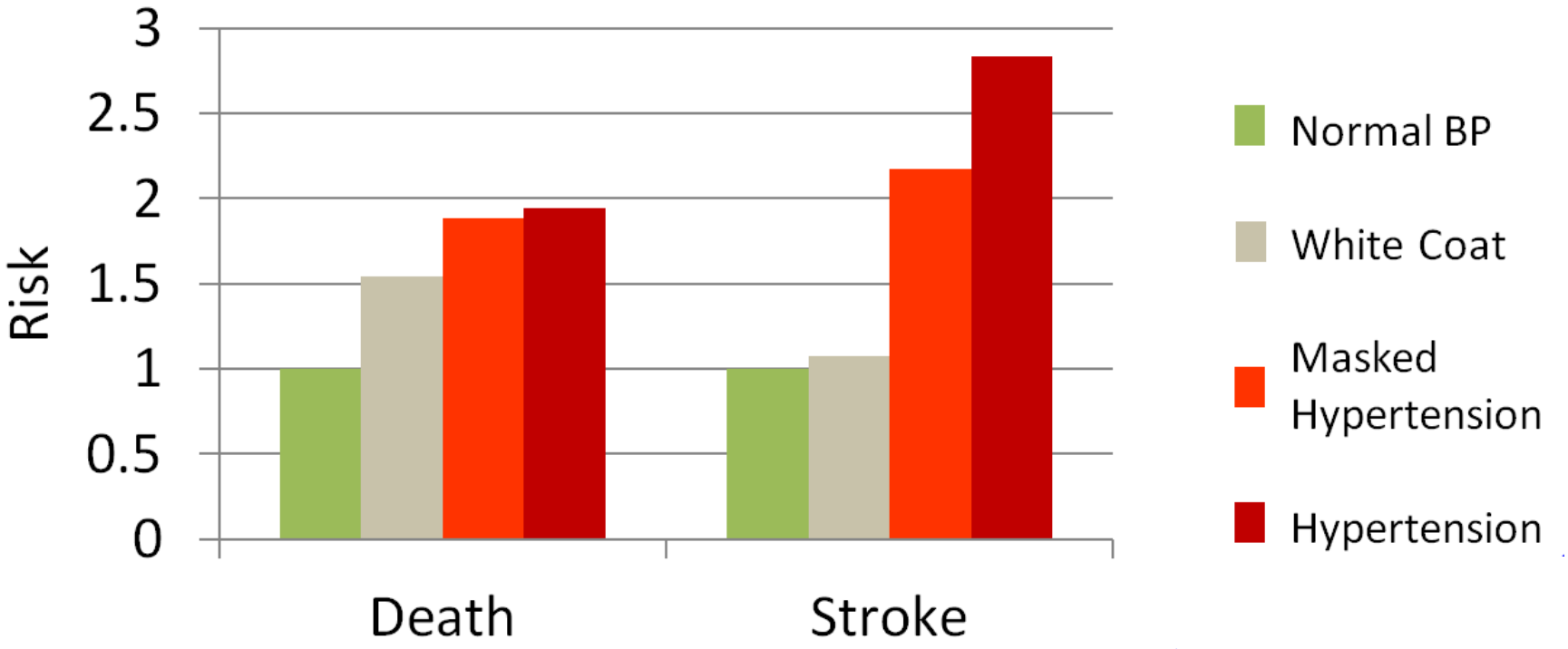
- Quality
  - 100% readings overall
- Mean overall BP: 142/84 mm Hg
- Mean awake BP: 148/89 mm Hg
- Mean sleep BP: 125/68 mm Hg
- Nocturnal dip: 15%/24%
- Systolic BP load: 74%

Predicting CVD outcomes

- "…systolic ABPM consistently and statistically significantly predicted stroke and other cardiovascular outcomes independently of office BP monitoring."

Ann Intern Med. 2015 Feb 3;162(3):192-204.

Risk by ABPM


Risk
3
2.5
2
1.5
1
0.5
0
Death
Stroke
Normal BP
White Coat
Masked Hypertension
Hypertension

Diagnostic accuracy of office BP

First author, year	Proportion Confirmed by 24-hr ABPM	95% CI	Screened, n
Kario, 1993	0.89	0.85-0.93	239
Inden, 1998	0.88	0.83-0.93	
Pierdomenico, 1995			255
Khoury, 1992	0.52	0.43-0.60	131
Hozawa, 2002	0.35	0.27-0.42	150

Got it right 35% to 89% of time

First author, year	Proportion confirmed by daytime ABPM	95% CI	Screened, n
Myers, 2010	0.93	0.87-0.99	69
Hond, 2003b	0.92	0.89-0.96	247
Gustavsen, 2003	0.90	0.88-0.93	420
Zawadzka, 1998	0.86	0.83-0.90	410
Verdecchia, 1995	0.81	0.79-0.83	1333
Graves, 2010		83	313
Celis, 2002		32	419
Manning, 1999		3	186
Nasothimiou, 2012	0.77	0.73-0.81	361
Fogari, 1996	0.74	0.68-0.80	221
Ungar, 2004	0.74	0.70-0.78	388
Gerc, 2000	0.65	0.62-0.67	1466
Passanha, 2013	0.61	0.56-0.67	336
Martinez, 1999	0.61	0.55-0.66	345
Talleruphuus, 2006	0.54	0.44-0.63	108
Zabludowski, 1992	0.47	0.40-0.55	171

Got it right 47% to 93% of the time

Practical issues: pitfalls

- *ABPM not yet widely available*
  - Few providers/clinical staff trained
- Recommended during a work day
- Limits some physical activity
- While tolerable, it is inconvenient
- A session of insufficient readings is possible (which would necessitate repeat)

Tolerability

- Most bother is interference with normal sleeping pattern
  - 67% reported that the monitor woke them after falling asleep, and 8.6% removed it at some point during the night
- Adverse effects: discomfort (32%), skin irritation (37%), and bruising (7%)

Viera et al. BMC Med Res Method 2011;11:59.

Note that ABPM has other clinical indications

- Confirm hypertension in children
- Resistant hypertension
  - Up to a third of such patients have controlled ABP
- Labile hypertension
- Hypotensive episodes
- Postural hypotension

Keys to successful ABPM

- Patient preparation
- Clear communication about what to expect
- Proper fitting and instructions provided
- Our team has high success: in one study of repeated wearing, 408 out of 420 with quality data X2 sessions

Home BP monitoring

- Another method to obtain measurements outside the clinical setting
- Also better predictor of outcome than office BP
- Evidence base is growing, but not as strong

Home BP monitoring

- May be a more feasible method
- Widely available
- Relatively affordable (or could be loaned or given as a gift, particularly for research)
- Systematically performed, home BP averages correlate reasonably well with daytime ABPM average

Definitions

- “Cut-offs” for home BP monitoring:

	Cut-off (mmHg)
Awake average	135/85
Nighttime (sleep) average	N/A
24-hour average	N/A

Home BP measurement protocol

- Have the patient commit to a minimum of five consecutive days of measurement
- Each day, patient takes 3 consecutive morning and 3consecutive evening measurements
- Discard the first two days' measurements and the first measurement of each triplicate set of measurements
- Average the remaining measurements

Home BP monitoring pitfalls

- Misses large segments of day (and nocturnal)
- Relies on proper technique
- Dependent on patient effort / engagement
- Concerns over “trustworthiness” of data

Home BP monitoring: value beyond diagnosis

- Monitoring BP control
- Evaluating possible medication side effects
- Improving BP control (encouraging adherence)

HBPM should be taught

- MA or RA should review technique, frequency (may vary by purpose), recording of measurements
- Must make sure cuff size is correct
- Some research suggested patients selectively record or do not record BPs correctly
- Some equipped with memory and printer

Take away message

- While commonly used in research studies, office or clinic visit BP measurements may not provide accurate estimates of a person's "true" BP
- Ambulatory BP monitoring is the best method for assessing BP, but is a mild inconvenience and may not be routinely available
- Home BP monitoring is another option for obtaining out-of-office measurements, but is limited by participant factors

Thank you for your attention!

If you want to learn more….

The Ready Clinician's™

Ambulatory BP Monitoring Training Course

September 10th in Tysons Corner, Virginia

www.abpmcourse.com

- Morning didactic sessions
- Afternoon hands-on training
- Opportunities to evaluate monitors and software