Changing Relationship Among Office, Ambulatory, and Home Blood Pressure With Increasing Age
A Neglected Issue

George S. Stergiou, Angeliki Ntineri, Anastasios Kollias

In this issue, Conen et al reported data showing changing relationship between office blood pressure (OBP) and awake ambulatory BP (aABP) with increasing age. This observation is not new, but it is largely neglected and ignored and has major clinical implications.

BP is known to increase with aging, leading to increasing hypertension prevalence. This applies to BP measurements in and out of the office (Figure). The problems start here because, as Conen et al confirmed, the range of BP rise with age is much higher (about double) for OBP than aABP. As a result, a practical problem emerges because the relationship between OBP and aABP is not the same across all the age groups.

There is convincing evidence that in children and adolescents the relationship among OBP, aABP, and home BP (HBP) is not the same as in the adults. A comparison of normalcy tables currently recommended for defining hypertension in children and adolescents showed that the corresponding percentiles are consistently lower for HBP than for aABP. Moreover, there is a trend for OBP to be lower than HBP and aABP in younger children, yet this difference is progressively eliminated with increasing age. The findings in regard to aABP might be attributed to high level of physical activity of the young individuals during the day (increases aABP), whereas the findings for HBP might be because of inability of the young children to remain still during repeated HBP measurements (increases HBP) (Table). The latter observation is changes (probably a progressive change) and which factors interfere (Table).

In 2011, Ishikawa et al published a meta-analysis of 34 studies (n=16148) investigating the relationship between office and out of office BP with increasing age (Figure). This analysis included untreated normotensives or hypertensives aged from 10 to >90 years with OBP and either aABP or HBP measurements. The conclusion was that systolic OBP increases with age more steeply than aABP and becomes higher than aABP after the age of 50 years. HBP was lower than OBP at all ages and also lower than aABP in younger subjects becoming similar in older ones.

In 2010, we reported data from 696 subjects aged 5 to 78 years, all of whom had OBP, aABP, and HBP measurements using the same protocol. The main conclusion was that (1) in children and adolescents aABP is higher than HBP and OBP and (2) in older subjects the aABP–HBP difference is eliminated and the aABP–OBP difference is progressively inverted. We recently expanded this data set and performed an updated analysis in 642 untreated subjects aged 5 to 78 years (unpublished data) and confirmed that (1) the crossing age point where aABP becomes higher than OBP is at 21 years and (2) HBP is lower than aABP in children, adolescents, and young adults up to the age of 40 years, and then tends to have similar values up to 60 years, and later on might be higher than aABP (Figure).

The key finding presented by Conen et al is that OBP is lower than aABP up to the age of 50 years, and this relation is reversed in older subjects (Figure). This change in the OBP–aABP relationship resulted in low prevalence of white-coat hypertension and high of masked hypertension in young people, and the reverse in old ones. Strengths of this analysis are that (1) it is based on random population studies, (2) included a large sample (n=9550), and (3) all were untreated for hypertension. Limitations are that (1) an incomplete picture of the age spectrum is provided because children and adolescents were not included, (2) there are no HBP data, (3) OBP was based on 2 readings on a single occasion, which is too little information for a measure known to be unstable and poorly reproducible, (4) OBP was obtained at the person’s home or at an examination center, whereas the diagnostic HBP threshold is not the same as for OBP; and (5) these findings are based on untreated population samples and may differ in subjects with elevated BP or treated for hypertension.

Common in the 3 studies comparing OBP with aABP is the age point of change after which their relationship is reversed with higher OBP than aABP. This is at 50 years in the data by Conen et al and Ishikawa et al compared with 21 years in

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Diagnostic disagreement is inevitable when using >1 BP measurement methods in clinical practice and getting around this problem is a challenge. Moreover, in the individual patient the OBP–aABP relationship is unpredictable. OBP is based on 2 to 3 measurements taken in an artificial setting, whereas aABP is based on 30 to 50 readings taken in the individual’s usual environment and activities. Therefore, it is not a surprise that ABP is a much stronger predictor of cardiovascular risk than OBP, and in case of diagnostic disagreement between them (white-coat or masked hypertension), the risk is dictated by ABP. For these reasons a straightforward approach would be to retain OBP for wide scale screening, but when ABP is available to base decisions exclusively on this method and ignore OBP. As for the diagnostic ABP threshold, indeed this has been derived from outcome studies in adults aged >50 years. In young people such studies are not feasible and distributional criteria have been used to define ABP thresholds in children and adolescents. Defining ABP normalcy through its relationship with preclinical organ damage (left ventricular mass) is a sensible approach for young subjects that needs to be addressed in future studies.

Table. Factors Affecting Blood Pressure Measured by Different Methods in Young and Old Subjects and Implications

<table>
<thead>
<tr>
<th>Age</th>
<th>Factors</th>
<th>Effects</th>
<th>Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young</td>
<td>↑ Physical activity; job strain</td>
<td>↑ Awake ABP</td>
<td>↑ Prevalence of masked hypertension</td>
</tr>
<tr>
<td></td>
<td>Unable to remain still during repeated home BP monitoring (children)</td>
<td>↑ Home BP</td>
<td></td>
</tr>
<tr>
<td>Old</td>
<td>↓ Physical activity; retirement</td>
<td>↓ Awake ABP</td>
<td>↑ Prevalence of white-coat hypertension</td>
</tr>
<tr>
<td></td>
<td>↑ Orthostatic hypotension</td>
<td>↓ Awake ABP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>↑ Prevalence of hypertension</td>
<td>↑ Office BP</td>
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<tr>
<td></td>
<td>and thereby of white-coat</td>
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<td>phenomenon</td>
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<td></td>
<td>phenomenon</td>
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</table>

ABP indicates ambulatory blood pressure; and BP, blood pressure.

References

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George S. Stergiou, Angeliki Ntineri, Anastasios Kollias

既然已经知道年轻受试者OBP, aABP和HBP之间的关系与成年人不同,一个明显的问题就是什么年龄这种关系会发生改变（可能是一种渐进的变化）以及有哪些介入因素（表1）。

2001年, Ishikawa等[1]发表了一项包含34项研究 (n=16148) 的meta分析, 探求随着个体年龄的增加诊室内外及诊
室血压之间的变化关系（图1）。该分析纳入10~90岁采
用OBP以及aABP或HBP测量的未经治疗的血压正常者或
高血压患者。结论是OBP收缩压随年龄增加而升高的程度
较aABP更为显著, 并且在50岁以上开始高于aABP。HBP
在所有年龄段均低于OBP, 且在较年轻受试者中也低于
aABP, 而在较老年者间开始变得相似。

2010年, 我们报道了696例年龄在5~78岁受试者的研究
数据, 采用相同研究方案检测所有受试者的OBP, aABP和
HBP[8]。其主要结论是: (1) 在儿童和青少年中, aABP高于
HBP和OBP; (2) 在较老年受试者中, aABP与HBP之间的差
异消失,而aABP与OBP之间的差异逐渐逆转。最近, 我
们扩展了该数据集, 针对5~78岁642例未经治疗的受试者进
行了重新分析（数据未发表），并且证实：(1) aABP开始高
于OBP的交叉年龄点为21岁；(2) 在儿童、青少年和40岁以
下青少年中HBP低于aABP, 之后两者数值趋近, 直至60岁,而
后HBP可能高于aABP (图1)。

Conen等[1]研究的主要发现是50岁前OBP低于aABP,而
在较老年受试者中这一关系发生逆转（图1）。OBP与
aABP之间关系的这种变化导致了年轻人中白大衣高血压
的患病率较低,而隐蔽性高血压的患病率较高, 老年人中则相
反。这项分析的优点在于: (1) 建立在随机人群研究的基础
上; (2) 纳入的样本量大 (n=9550); (3) 所有受试者均未
经高血治疗。其局限性包括: (1) 由于未纳入儿童和青少
年, 故所提供的年龄谱不完整; (2) 无HBP数据; (3) OBP
than OBP, and in case of diagnostic disagreement between ABP is a much stronger predictor of cardiovascular risk in the usual environment and activities. Therefore, it is not a surprise that ABP is based on 30 to 50 readings taken in the individual’s awake ambulatory blood pressure. Constructed from data reported by Conen et al,1 Ishikawa et al,2 and Stergiou et al.3

In other studies1–3 prevalence (elevated aABP), which was almost double across all the age groups in our study that included subjects attending a BP clinic.3 In the studies by Conen et al,1 Ishikawa et al,2 and Stergiou et al.3 the OBP–aABP relationship is unpredictable. OBP is based on 2 to 3 measurements taken in an artificial setting, whereas the prevalence of hypertension seems to be largely driven and explained by differences in hypertension threshold based on awake ambulatory blood pressure. Constructed from data reported by Conen et al,1 Ishikawa et al,2 and Stergiou et al.3

Figure 1. Using different methods in clinical practice and getting around the white-coat phenomenon. In other studies,5–7 the prevalence of the white-coat phenomenon. In other studies,5–7 the prevalence of the white-coat phenomenon was at ≈130 mm Hg in all the 3 studies (Figure).1–3 Thus, there is a difference reversal (50, 50, and 21 years, respectively) aABP in the prevalence (elevated aABP), which was almost double across all the age groups in our study that included subjects attending a BP clinic.3 In the studies by Conen et al,1 Ishikawa et al,2 and Stergiou et al.3

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<table>
<thead>
<tr>
<th>年龄</th>
<th>影响因素</th>
<th>效应</th>
<th>意义</th>
</tr>
</thead>
<tbody>
<tr>
<td>老年人</td>
<td>体力活动; 退休</td>
<td>降低</td>
<td>隐匿性高血压的患病率</td>
</tr>
<tr>
<td>年轻人</td>
<td>体力活动; 工作压力</td>
<td>增加</td>
<td>OBP中无法保持安静（儿童）</td>
</tr>
<tr>
<td>老年人</td>
<td>直立性低血压</td>
<td>隐匿性高血压的患病率</td>
<td></td>
</tr>
<tr>
<td></td>
<td>高血压的患病率以及由家庭BP引起的白大衣现象</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ABP, 动态血压; BP, 血压。