Evaluation of skills and knowledge on orthostatic blood pressure measurements in elderly patients

Lilian C. M. Vloet, Rita Smits, Carla M. A. Frederiks, Willibrord H. L. Hoefnagels, René W. M. M. Jansen

University Medical Center Nijmegen, 318, Department of Geriatric Medicine, PO Box 9101, 6500 HB, Nijmegen, The Netherlands

Abstract

Objectives: orthostatic hypotension is a common and potentially dangerous condition in elderly patients, often accompanied by dizziness and falls. To diagnose orthostatic hypotension, many physicians rely on blood pressure measurements performed by nurses.

Design: observational and descriptive study.

Setting: departments of Internal Medicine, Geriatric Medicine, and Surgery in eight hospitals throughout the Netherlands.

Subjects: 170 nurses working with elderly people in a general hospital. We selected a sample of 10 nurses on 17 participating wards.

Methods: to evaluate nurses’ skills and knowledge on blood pressure measurements to diagnose orthostatic hypotension, we performed standardized observations, based on published guidelines, of supine and standing blood pressure determination in patients over 65 years.

Results: the most important deviations in technique of orthostatic blood pressure measurement from the published guidelines were: time between measuring supine and standing blood pressure varied from 0–30 minutes; in 28% the arm position was not at heart level during standing blood pressure measurements; in 46% the cuff was placed incorrectly.

Conclusions: the skills and knowledge of nurses to measure supine and standing blood pressure are inaccurate for diagnosing orthostatic hypotension in elderly patients. Large differences in measurement technique and timing of standing blood pressure could influence the individual detection and treatment of orthostatic hypotension and the reported prevalence of orthostatic hypotension. The blood pressure measurement procedure to diagnose orthostatic hypotension needs more standardization and implementation of guidelines in daily practice.

Keywords: aged, blood pressure measurement, diagnostic errors, orthostatic hypotension, skills

Introduction

Orthostatic hypotension (OH) is commonly observed in frail elderly people and may contribute to dangerous and serious morbidity such as dizziness, syncope and falls [1–5]. The prevalence of OH in unselected elderly people ranges from 5% to 30% [1, 6]. It is greater in institutionalized populations [7] and increases with age [2]. OH is a predictor of mortality in elderly men [8] and for stroke [9]. Elderly people with highly variable orthostatic blood pressure (BP) measurements have an increased risk of stroke [10].

OH is commonly defined as a decline of 20 mm Hg or more in systolic BP or 10 mm Hg or more in diastolic BP after standing [4, 11]. Although there is no standard method for the detection of OH [4], several
authors suggest optimal position and timing for BP measurement that should be followed in the evaluation of OH [1, 3, 11–13].

Accurate measurement of blood pressure in the clinic is of paramount importance in the assessment and modification of cardiovascular risk [14]. To diagnose OH, physicians in many countries rely on BP measurements performed by nurses. Therefore, it is critical to know how accurately these measurements are performed. However, detailed information on the skills and knowledge of nurses for the performance of orthostatic BP measurements is scarce. Since OH is such a common, potentially dangerous condition in elderly patients and accurate BP measurement is important, we investigated skills and knowledge of orthostatic BP measurements in elderly patients by registered nurses in general hospitals in the Netherlands.

Methods

Subjects

The subjects of this study were 170 registered nurses working at 17 different departments in eight hospitals throughout the Netherlands (Table 1). The departments of Geriatric Medicine, Internal Medicine, and Surgery were chosen because of the high percentage of elderly patients admitted to these wards. We invited all nurses in the 17 departments to participate. We selected a sample of 10 nurses of the participating wards by the working schedule, taking all nurses working on the specific day that this study was performed.

Instrumentation and procedure

The nurses technique in recording orthostatic BP measurements was evaluated in a two-part test. The first part evaluated the practical performance. We asked the participating nurses to measure supine and standing BP with a sphygmomanometer in a patient over 65 years in their usual way. One of the investigators (RS) made observations according to a standardized protocol based on the American Heart Association (AHA) recommendations for BP measurement [15] and the pertinent research literature [1, 3, 4, 11–13, 16–18]. The American Academy of Neurology’s consensus statement definition of OH was used in our study-protocol for the BP measurement part on OH [11]. The investigator, who had previously been trained to follow the standardized protocol, made all observations at the time of the day when the orthostatic BP measurements were usually taken in the different departments [3, 11–13, 15].

The participating nurses were informed about the procedure shortly before the observation in order to prevent preparation and minimise consulting with or influencing nursing colleagues.

In the second theoretical part of the test, a standardized set of questions was asked about details of the BP measurement procedure and information about the age, sex, education and experience of the nurses.

Data analysis

All dichotomous variables in the questionnaire were analysed in SPSS 8.0 for Windows (SPSS Inc., Chicago, IL, 1998) using simple descriptive statistics. A total score of all parts of the BP measurement procedure was used to give a final analysis on the nurses’ BP skills. The Kruskal-Wallis test was used to compare the means of the three departments. The $\chi^2$ test was used to compare the scores of individual nurses. We compared nurses working in Geriatric, Internal Medicine, and Surgical departments and in general and university hospitals, to establish if specialty or working in a university hospital influenced the outcomes of BP measurement skills. A $P$-value of less than 0.05 was considered as statistically significant. Data are presented as group means ± SD, unless indicated otherwise.

Results

Subject characteristics

The subject characteristics are presented in Table 1. There was no significant difference in experience, education or age between the participating departments.

Overall results of the BP measurements

The most important results of the nurses’ performance on BP measurements are presented in Table 2 as mean of all nurses and split by department. The departments of Internal Medicine had the best overall results of BP measurements ($P<0.001$). Three Geriatric, three Surgical and all five Internal Medicine departments used a protocol for general manual BP recordings. Only one department of a general hospital used a protocol for measuring orthostatic BP but their results were not significantly different from the other departments for any of the observed items. In university hospitals, the BP measurements followed guidelines to a significantly greater extent than in general hospitals ($P<0.001$). The skills and knowledge of nurses with less experience (0–1 year) and nurses with longer experience (>5 years) were not significantly different.

Preparation of blood pressure measurement

In 16% of the BP measurements, the supine rest was less than the recommended 5 minutes [15]. Eighty-nine percent of the nurses used the correct cuff-size [15, 19].
In 46% of all BP measurements, the cuff was not placed with the bladder centred over brachial artery [15].

The equipment

In 22% of all BP equipment—and significantly more in the Geriatric departments (48%)—the mercury column of the sphygmomanometer was not in the vertical position ($P<0.001$) [15]. In 9% of all equipment, the mercury column was not at zero before inflation [15, 20].

The BP measurement

In 72% of all standing BP measurements, the patient’s arm was at heart level (an unsupported arm gives a falsely higher BP [14, 15, 17]). Eye level position of the sphygmomanometer, were not achieved in 38% of all observed BP measurements in the lying position and in 49% of all standing measurements. The guidelines recommend that BP levels should always be recorded in even numbers and read to the nearest 2 mm Hg mark on the manometer [15]. Ten percent of all nurses rounded BP readings up to the nearest 2 mm Hg, the others to 5 mm Hg [15, 20].

Measuring standing BP

The time between standing up and measuring the first upright BP varied from 0–30 minutes. Six of the 170 nurses walked out of the room and came back after

### Table 1. Subject characteristics of participating nurses ($n=170$)

<table>
<thead>
<tr>
<th>Number of nurses</th>
<th>Total group $n=170$</th>
<th>Geriatric Medicine $n=80$</th>
<th>Internal Medicine $n=50$</th>
<th>Surgery $n=40$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nurses per setting</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>University hospitals</td>
<td>80</td>
<td>20</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>General hospitals</td>
<td>90</td>
<td>60</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean±SD</td>
<td>33.8±8.7</td>
<td>34.1±8.6</td>
<td>34.9±8.0</td>
<td>32.3±9.4</td>
</tr>
<tr>
<td>Range</td>
<td>21–56</td>
<td>21–51</td>
<td>24–56</td>
<td>21–53</td>
</tr>
<tr>
<td>Experience (years)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean±SD</td>
<td>10.0±8.2</td>
<td>9.2±7.7</td>
<td>11.3±8.5</td>
<td>9.8±8.7</td>
</tr>
<tr>
<td>Range</td>
<td>0–33</td>
<td>0–30</td>
<td>0–28</td>
<td>0–33</td>
</tr>
</tbody>
</table>

### Table 2. Results of standing and supine BP measurements for diagnosing OH by nurses

<table>
<thead>
<tr>
<th></th>
<th>Total group Mean (±SD)</th>
<th>Nurses working at the departments of</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$n=170$</td>
<td>Geriatric Medicine $n=80$</td>
</tr>
<tr>
<td>Supine rest for at least five minutes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arm at heart level during recording BP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of appropriate cuff size</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cuff placed correctly on the brachial artery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mercury column vertical on wall or desk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mercury column starting at zero</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Record BP in the patients’ chart</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Record time between standing up/recording</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BP measured to the nearest 2 mm Hg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading BP at eye level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patients arm at heart level while standing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measuring BP immediately after standing up</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measuring BP 1 minute after standing up</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measuring BP 2 minutes after standing up</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measuring BP 3 minutes after standing up</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measuring standing BP after &gt;3 minutes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measuring several times standing in one session</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measuring several occasions on different days</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

All departments are compared with the other departments.

$^aP<0.05$.

$^bP<0.001$.

BP=blood pressure.
15–30 minutes with the intention to measure standing BP for diagnosing OH. In these cases, patients performed activities that could influence BP. Ninety percent of all nurses stated that they measured supine and standing BP on several occasions, at different times of day, and on different days for diagnosing OH.

**Documentation**

Nurses measured supine and standing BP at variable times of the day, depending on their personal daily practice. Of all nurses, 51% did not record the time of BP measurements in the patient’s chart. In the departments of Surgery and Internal Medicine, measurement time was reported in 53% and 64%, respectively; in the department of Geriatric Medicine it was significantly less (30%) (P<0.001). In university hospitals the time of BP measurements was reported in 68%; in general hospitals it was significantly less (25%) (P<0.001). Circumstances that could have influenced the BP recordings (such as medication) were documented in 65% of all cases. Nurses made an inventory of the patients’ complaints in 95% of cases and documented symptoms in the patient’s chart in 99%.

**Discussion**

Accurate measurement of supine and standing BP plays an important role in the diagnostic process [14] and assessment of OH. However, the findings of this study indicate that nurses show great differences in their skills and knowledge needed to measure orthostatic BP by sphygmomanometry. This can lead to inaccurate BP readings for diagnosing OH in elderly patients. The large range in time that elapsed between standing up and BP measurements indicates that strict procedures and protocols are lacking and standardization of the technique is needed.

BP measurements can be influenced by patient factors [12, 15, 20, 21], observer factors (such as sight or hearing problems [15, 20, 21]) factors related to skills and knowledge [12, 16, 20, 21] or factors related to the BP measurement equipment [3, 15, 20, 21]. Previous studies, which evaluated knowledge and performance of BP measurements, only focussed on BP measurements in general [16, 22, 23]. No studies were found on skills and knowledge of orthostatic BP measurements. In our study, we not only focussed on general BP measurement skills but especially on standing BP measurements for the detection of OH.

In clinical practice, the first and third minute after standing are the most practical and most useful times to diagnose orthostatic BP changes [1, 3, 24]. In this study, only 8% of the nurses measured BP more than once after standing. There was also a large variation in upright standing time intervals from 0–30 minutes. The differences in measurement technique and timing of standing BP could interfere with the individual detection of OH and give a wrong estimate of the overall prevalence [1, 2, 6, 7]. This could also explain the range in prevalence of OH in performed studies [1, 2, 6, 7].

Other important findings in this study were that despite the correct choice of cuff size, the cuff was placed incorrectly in 40% of the BP measurements, which overestimates the BP-readings [15, 19]. The great influence on BP of small deviations of the arm beyond heart level seems to be ignored: in a quarter of the BP measurements, the arm was not at heart level [17]. This gives falsely high BP levels [14, 15]. The erratic position of the mercury column (no vertical position) also makes it difficult to assure the accuracy of BP-readings. With the growing interest of the use of automatic oscillometric devices, some of the errors in measurement technique could be reduced. However, most of the major errors found in this study (such as at least 5 minutes of supine rest to reach baseline blood pressure and measuring at fixed time points after standing) are not related to the measuring device and remain very important. Therefore, these major errors are not due to the use of equipment, but to the lack of knowledge and a standardized procedure for diagnosing orthostatic hypotension.

An important limitation of our study is that there was no standard protocol for measuring standing BP which could be used to evaluate the orthostatic BP measurements performed by nurses. The significant differences between nurses and between departments regarding standing BP measurements underscore the importance of translating the recommendations of several authors on orthostatic BP measurements into guidelines, and implementing these guidelines in daily practice [1, 3, 4, 11–13, 24]. Although the results of this study are restricted to the Netherlands and cannot be generalized to physicians, the literature suggests that similar problems in BP measurement exist for qualified doctors, medical, and nursing students [22, 23, 25, 26]. Carney et al. concluded that the knowledge of the medical and nursing staff and technical ability in sphygmomanometer use was similar in doctors and nurses [27].

We did not measure BP simultaneously with a Y-stethoscope to investigate if correct BP measurement technique leads to over- or underestimation of OH, as it would have influenced the procedure (for example, by measuring BP at different time points). Because of the large day-to-day and within-day variability of OH [1, 4, 28], measurement of BP in the correct way on any other occasion to compare the results with the outcomes of the nurses’ BP readings was also impossible. Villegas et al. did measure BP by strictly following the AHA guidelines, directly after observing their subject’s measurement [23]. They found that 63% of the systolic BP readings and 53% of the diastolic readings were out of range and inaccurate, compared to BP measurements according to guidelines. Although we tried to prevent preparation, the data were not completely independent.
because communication between colleagues could not be totally avoided.

We conclude that BP measurement skills and knowledge of nurses working with elderly patients in different departments of Internal and Geriatric Medicine and Surgery can lead to inaccurate BP recordings for the diagnosis of OH. The most important steps in the BP measurement routine which can lead to erroneous BP results or misinterpretation of the BP readings that most nurses failed were: placing the cuff at the upper arm incorrectly and measuring standing BP only once at variable time points after standing. OH is, if measurements are performed well, an easily obtained measurement to identify elderly patients at risk of stroke. The variability of orthostatic BP should be examined rather than relying on one single blood pressure measurement [10]. Choosing the right cuff size, correct documentation, and recording patients’ complaints were performed well by almost all nurses. Uniform definition and measurement of the BP response to standing is critical for correct interpretation of BP data and diagnosing OH. If the clinical practice of diagnosing OH is to improve, development and implementation of guidelines for the measurement of orthostatic BP changes is needed, followed up by a continuing post-nursing school education programme. With a correct diagnosis, based on proper BP measurements, elderly patients with treatable OH could be discovered and OH-related co-morbidity could be prevented or alleviated.

**Key points**

- Accurate measurement of blood pressure is very important for diagnosing orthostatic hypotension.
- The skills and knowledge of nurses in measuring supine and standing blood pressure are inaccurate for diagnosing orthostatic hypotension in elderly patients. Because of the lack of standardized guidelines to measure orthostatic hypotension, physicians cannot rely on blood pressure measurements without giving further instruction on when and how to measure supine and standing blood pressure to diagnose orthostatic hypotension.
- The most important deviations in skills and knowledge of orthostatic blood pressure measurements from the published guidelines were: time between measuring supine and standing blood pressure varied from 0–30 minutes; in 28% the arm position was not at heart level during standing blood pressure measurements; in 46% the cuff was placed incorrectly.
- Large differences in measurement technique and timing of standing blood pressure could influence the individual detection and treatment of orthostatic hypotension and the reported prevalence of orthostatic hypotension.
- The blood pressure measurement procedure to diagnose orthostatic hypotension needs more standardization and implementation of guidelines in daily practice.

**Orthostatic blood pressure measurement**

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