Lack of Alerting Reactions to Intermittent Cuff Inflations During Noninvasive Blood Pressure Monitoring

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SUMMARY Intermittent noninvasive blood pressure monitoring is becoming increasingly popular because of the belief that a daytime blood pressure profile can provide a better clinical evaluation of hypertension than that provided by casual blood pressure measurements. This approach has potential limitations, however, one of which is that the cuff inflations permitting blood pressure to be repeatedly measured may induce an alerting reaction and a pressor response in the patients and lead to an overestimation of their daytime blood pressure. Blood pressure in 22 subjects was invasively recorded for 24 hours by the Oxford method. During the day of the recording blood pressure was also measured by a noninvasive device (Vita-Stat 901), which had its cuff applied to the opposite arm from which the intra-arterial signal was derived. For 2 hours the device provided automatic cuff inflations at 10-minute intervals. For another 2 hours it was programmed to provide cuff inflations only following patients' commands, also at 10-minute intervals. Analysis of the intra-arterial blood pressure trace during the periods preceding and following the automatically or semiautomatically induced cuff inflations showed that these procedures caused no increment in systolic and diastolic blood pressure. This finding applied not only to the mean data but also to each individual measurement considered separately, including the initial one. Our results indicate that automatic and semiautomatic blood pressure monitorings do not induce an alarm reaction and a blood pressure rise and thus do not overestimate daytime blood pressure values.

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KEY WORDS • noninvasive blood pressure monitoring • alerting responses • stress • hypertension • blood pressure

USE of devices that allow periodical automatic or semiautomatic blood pressure measurements is becoming increasingly popular in the clinical evaluation of hypertensive patients. It is believed that these measurements can estimate the daytime blood pressure profile, which may make the diagnosis of hypertension and the prediction of its role in determining cardiovascular morbidity more accurate than that possible with casual blood pressure assessments.

Several theoretical and practical aspects of the automatic and semiautomatic blood pressure measuring devices still need to be investigated, however. One of these aspects is the possibility that the intermittent cuff inflations allowing blood pressure to be repeatedly measured induce discomfort and anxiety in the patient, which results in a blood pressure elevation. This drawback could limit the ability of these devices to supply real daytime blood pressures as well as question their overall validity.

We examined this issue in 22 subjects by combining intermittent automatic or semiautomatic blood pressure measurements with intra-arterial blood pressure monitoring.

Subjects and Methods

Our study was performed in 22 hospital inpatients (17 men, 5 women), ranging in age from 19 to 70 years (mean, 43.5 ± 14.4 yr). All subjects had been classified as having mild or moderate essential hypertension. Treatment had been discontinued in all subjects at least 1 week before admission to the hospital. All subjects gave informed consent.
Blood Pressure Recordings

In each subject blood pressure was recorded intra-arterially using the Oxford method (Oxford Instruments, Oxford, UK), which has previously been described in detail. Briefly, a catheter was placed in a radial artery after local anesthesia with 2% lidocaine. The catheter was connected through a rigid-walled polyethylene tube to a small Plexiglas box bound to the patient's thorax at the level of the heart. The box contained a 40-ml saline reservoir pump unit (operated by a small battery) that provided the catheter with a constant slow perfusion to keep it patent for 24 hours. It also contained a blood pressure minitransducer connected to a battery-operated amplifier and to a tape recorder fastened to the subject's waist. The tape recorder allowed the 24-hour blood pressure signal to be stored in a minicassette. The stability of the zero signal, the linearity of the transducer, and the adequacy of the frequency response curve of the tubing-amplifier-recording system were checked before and after the 24-hour period to ensure that no error had affected the blood pressure recording. No subject complained of pain or discomfort as a result of the procedure. Indeed, the small size and weight of the various parts of the device enabled the subjects to move freely within the hospital area and to engage in the social activities of inpatients.

During the intra-arterial blood pressure recording blood pressure was also monitored by a noninvasive commercially available device (Vita-Stat 901, Vita-Stat Medical Devices, Inc., St. Petersburg, FL, USA). The cuff of the Vita-Stat was applied to the arm not used for the intra-arterial blood pressure measurements. The device was programmed to provide automatic cuff inflations at 10-minute intervals for 2 hours during the day. It then was programmed to provide cuff inflations only following the subject's command (i.e., semiautomatically), given approximately every 10 minutes for another 2 hours. During both periods the subjects were told to remain supine in bed beside the noninvasive blood pressure recording apparatus. They were also told to press a marker that could identify the time of the cuff inflation on the intra-arterial blood pressure trace. Throughout the study the subjects were left alone in a quiet room to minimize the occurrence of environmental disturbances that could affect blood pressure. Of the 22 patients, 13 completed the automatic and the semiautomatic recording period without any disturbance; two completed only the automatic recording period, and seven completed only the semiautomatic recording period.

Data Analysis

Data were analyzed as follows. At the end of the 24-hour blood pressure monitoring the intra-arterial blood pressure signal derived from the minicassette was recorded on a Grass polygraph (Grass Instrument Co., Quincy, MA, USA) at a speed of 60 mm/min. Pulsatile blood pressure was electrically damped to obtain separate recording of mean arterial pressure. Heart rate was obtained with a tachograph triggered by the pulsatile blood pressure signal. The blood pressure and heart rate tracings were analyzed for 1 minute immediately before the beginning of each cuff inflation, 1 minute immediately following the beginning of each cuff inflation, and 1 minute 5 minutes before the beginning of each cuff inflation (control period). For each minute the analysis consisted of calculations of systolic, diastolic, and mean arterial pressure and heart rate values taken at 15-second intervals. Data corresponding to all automatic or semiautomatic cuff inflations were averaged in each subject to obtain mean (± SD) effects of these two procedures for each subject. Mean individual data were further averaged to obtain means (± SE) for the group as a whole. Means (± SE) for the group as a whole also were calculated separately for the 12 cuff inflations (1 every 10 min for 2 hr) included in the 2-hour automatic or semiautomatic monitoring period. Differences between individual or group averages were evaluated by paired t test, and p < 0.05 was taken as the level of the statistical significance.

Results

The effects of automatic blood pressure measurements on the intra-arterial blood pressure values are shown in Figures 1, 2, and 3. Systolic blood pressure, diastolic blood pressure, mean arterial pressure, and heart rate showed no alterations during the minutes immediately before and after the beginning of the automatic cuff inflations. Furthermore, blood pressure and heart rate values measured in these periods were virtually identical to the values measured in the more distant period selected as control (5 min before cuff inflation). This finding was true for the group as a whole (see Figure 2) as well as for each of the 15 subjects in which this study was performed (see Figure 3).

The effects of semiautomatic blood pressure measurements on the intra-arterial blood pressure values are shown in Figures 1, 2, and 4. Semiautomatic blood pressure measurements caused no blood pressure and heart rate alterations during the minutes before and after the beginning of the cuff inflations, nor did they alter these values with respect to the values measured during the more distant control period. Separate analysis of the results in the 20 subjects in which this study was done (see Figure 4) showed that semiautomatic blood pressure measurements raised blood pressure or heart rate in only four subjects; however, this rise was either extremely short lived (Subjects 4, 9, and 15) or negligible in size (Subject 16).

Figure 5 shows the average blood pressure and heart rate values obtained in the group as a whole by separately considering the 12 cuff inflations included in the 2-hour automatic or semiautomatic blood pressure monitoring period (see Methods). Data are shown as changes from the average value of the corresponding control period. It can be seen that lack of blood pressure and heart rate alterations characterized all inflations regardless of their chronological order. Thus, there was no evidence of an initial hemodynamic effect of cuff inflation that might have disappeared with its repetition.
Figure 1. Tracings of intra-arterial blood pressure monitoring during automatic or semiautomatic cuff inflation. Arrow indicates the beginning of the automatically or semiautomatically induced cuff inflation. ABP = arterial blood pressure; MAP = mean arterial pressure; HR = heart rate.

Figure 2. Intra-arterial blood pressure and heart rate during the minute immediately preceding the beginning of cuff inflation (−1 to 0), the minute immediately following cuff inflation (0 to +1), and the 1-minute control period measured 5 minutes before cuff inflation. Values measured every 15 seconds are shown. Data refer to means ± SE for all subjects in which the effects of automatic and semiautomatic blood pressure measurements were studied. Arrows refer to the beginning of cuff inflation. S = systolic blood pressure; D = diastolic blood pressure; M = mean arterial pressure.

Figure 3. Data are shown (as in Figure 2) individually for 15 subjects in which the effects of automatic blood pressure measurements on intra-arterial blood pressure and heart rate (HR) were studied. Points represent means ± SD. Arrows indicate the beginning of cuff inflation. MAP = mean arterial pressure.
Discussion

In our study noninvasive blood pressure measurements were not accompanied by any short-lived or more prolonged increase in blood pressure and heart rate. This finding was true for all measurements performed throughout the study. It was, in particular, true for measurements performed automatically and for measurements performed following patients' commands (i.e., on a semiautomatic basis). These results indicate that such procedures do not induce an alarm reaction or trigger a condition (e.g., anxiety, fear) that may be associated with a rise in blood pressure. This should rule out errors of overestimation of patients' blood pressure and make it likely that automatic and semiautomatic monitoring provide true daytime blood pressure values.

Lack of a blood pressure rise during automatic or semiautomatic blood pressure measurements clearly contrasts with the variable but overall marked pressor responses that characterize blood pressure measurements made by a physician and, to a lesser extent, by a nurse. These phenomena are sufficient to move many subjects from the normotensive into the hypertensive range and to extend treatment (and its disadvantages) to many subjects whose blood pressure rises to mildly hypertensive levels only during measurements. In this context, the advantages offered by automatic and semiautomatic blood pressure assessments (which did not raise blood pressure even when applied for the first time; Figure 5) are unequivocal.

Although our study removes an important objection to the ability of automatic or semiautomatic blood pressure measuring devices to achieve average daytime blood pressure, it does not provide solutions to all major problems related to this approach. Intermittent cuff inflations may disturb a subject's sleep and prevent a correct estimation of 24-hour blood pressure profile, which could be an even better estimator of cardiovascular complications related to hypertension than daytime blood pressure. In addition, the accuracy of the blood pressure readings provided by the automatic and semiautomatic devices currently on the market, particularly when employed in ambulant subjects,
is still open to question. These problems must be remedied before these devices can be recommended for general clinical use.

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