

ORIGINAL RESEARCH

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Comparison of the arterial blood pressure of the arm, forearm, and ankle of smokers under general anesthesia

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Abstract

Arterial blood pressure (ABP) measurement of forearm and ankle have been suggested as an alternative site to measure blood pressures when the upper arm is unavailable. However, there is little evidence utilizing clinical populations to support this topic. The simultaneous measurement method is used for the left upper arm, forearm, and ankle blood pressures. Participants were eligible if they were aged 18 years or older, were able to consent, and able to have blood pressures measured on their left arm while lying at a 45° angle. The independent sample t-test method of statistical analysis was used, for the systolic, diastolic and mean arterial pressure defined. The ankle measure overestimated systolic (mean difference 10.8 mmHg, 95% limits of agreement ± 12.9 mmHg), diastolic (mean difference 14.7 mmHg, 95% limits of agreement ± 8.4 mmHg), and mean arterial pressures (mean difference 13.0 mmHg, 95% limits of agreement ± 8.9 mmHg). The systolic, mean and diastolic measure were no significantly different between smokers and nonsmokers groups. ABP disparity was associated with groups. In the study, ABP measurements from the arm which is a standard method with forearm and ankle ABP measurements; no differences were observed when comparing the groups that are smokers and non-smokers.

Keywords: Blood pressure, smokers, general anesthesia

Introduction

During general anesthesia, measurement of arterial blood pressure (ABP) is indispensable. ABP analysis is carried out indirectly using a non-invasive oscillotonometric method which is usually placed on the arm. In some cases, it is not possible to put the cuff on the arm. If the arm cannot be used due to intravenous (IV) way or surgical place intervention, it may be placed on the forearm or ankle alternatively [5].

Clinicians need to know the functionality of alternative ABP measurement places in terms of both efficiency and correctness. Prior studies have noted that ankle measurement of ABP than on the arm. [1,2]. In contrast, other studies examining alternative routes for ABP measurement used several patients and conditions [2,3], but in these studies, alternative sites were not simultaneously compared [4], but a suitable statistical approach was not used [3,5] or continuous did not evaluate availability.

In our study, we aimed to evaluate the accuracy, tenderness, and tendency of ABP, forearm, and ankle simultaneous ABP measurements in smokers and non-smoker general anesthesia patients.

Material and Method

Participants

After the approval of the Ethics Committee of Necmettin Erbakan University Meram Medical Faculty (2017/873), the patient's consent was obtained for participation in the study and 50 consecutive patients were included to the study who underwent general anesthesia. The age range of patients was between 18-65 years. We included at least one pack of cigarette users per day for more than 20 years in a group of regular smokers group. Patients with recognized heart or vascular disease and those with skin lesions that may cause problems in ABP measurements were excluded from the study. Preoxygenation with 100% oxygen was followed by induction of anesthesia with propofol (0.5 mg/kg), fentanyl (1.5 mcg/kg), rocuronium (0.6 mg/kg), and endotracheal intubation. Fentanyl, propofol, and rocuronium were administered for the maintenance of anesthesia. ABP measurements were noted intraoperatively in the arm, forearm and ankle at 5 minute periods.

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All measurements were performed in patients in the supine position. And arm position was 90 degree according to the vertical axis of the body.

Measurements

ABP was measured applying a calibrated standard anesthetic monitor (S / 5 anesthesia monitor; GE Healthcare, Waukesha, WI, USA). Three monitors were applied simultaneously to achieve simultaneous measurements and were randomly selected between the arm, forearm, and ankle using a random numbers table. Small, standard and large three cuff sizes were used. The size of the ABP cuff was chosen to cover at least 40% of the measured limb length [1]. Alternative arterial blood pressure measurement sites includes forearm (the radial artery region on the lateral side of the forearm) and ankle (the posterior tibial artery is located on the back of the medial malleolus).

Statistical methods

The anesthesia monitor noted systolic blood pressure (SBP) and diastolic blood pressure (DBP) measurements; this data was recorded in an Microsoft Excel® (Microsoft Office version 365, 2010, Redmond, WA, USA) database and provided for statistical analysis. Based on related studies attended earlier, the sample had a power of 80% to identify differences in a significance level of 5%, corrected for multiple comparisons between three measured zones, with more than 50 patients. This sample size was obtained by calculating the ± 0.4 SD measurement differences with the reliability limits and the 95% agreement limit.

Measurements of arterial blood pressure repetitive measurements were accepted based on a 20% error margin. Patients with 4 or more measurements were included in the calculation. For evaluating the relationship between measurements, independent samples t-test in the sense of linear trend was calculated. SPSS version 22 (SPSS, Chicago, IL, USA) was used to calculate the independent t-test. p-value 0.05 was considered statistically significant.

Results

Fifty patients (mean age, 38 yrs), male and female patients (76% and 24%) with a body mass index(BMI) range of 17 to 35 cm (mean BMI 26.45), participated in the study. When the groups compared as a male-female patients and body mass index(BMI). There was a statistical difference between the smoker and non-smoker groups. ($p=0.001$) And there was a statistical difference within the smoker and non-smoker groups. ($p<0.001$) When the ABP measurements compared within the group. There was a statistical difference within non-smoker groups. ($p<0.001$), but there was a statistical difference within smoker groups. ($p<0.05$) Meaningful statistical differences were not found between contemporary arm-forearm and arm-ankle SBP and DBP measurements. Graphical displays of the results were presented in a Scatter/Dot chart. Between the arm, forearm, and ankle (Figure 1). For SBP measurements, mean value 114.89 mmHg of simultaneous arm measurements were within ± 25.86 mmHg. For SBP measurements, mean value 127.73 mmHg of simultaneous forearm measurements were within ± 29.94 mmHg. For SBP measurements, mean value 129.87 mmHg of simultaneous ankle measurements were within ± 47.26 mmHg respectively. For DBP measurements, mean value 67.80 mmHg of simultaneous arm measurements were within ± 16.23 mmHg. For DBP measurements, mean value 77.69 mmHg of simultaneous

forearm measurements were within ± 19.99 mmHg. For DBP measurements, mean value 68.71 mmHg of simultaneous ankle measurements were within ± 19.59 mmHg respectively (Table 1).

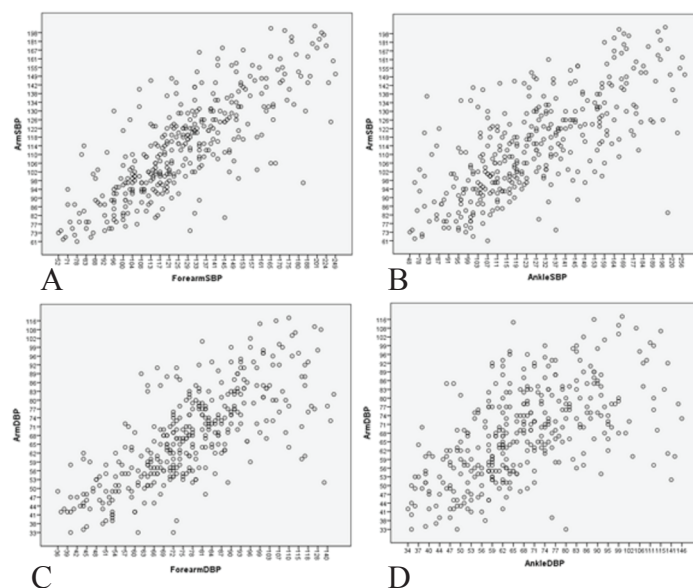


Figure 1. Scatter/Dot chart figures showing arm-forearm and arm-ankle differences for simultaneous systolic (SBP) and diastolic blood pressure (DBP) measurements (mmHg). Scatter/Dot charts: (A) Arm-forearm SBP differences; (B) arm-ankle SBP differences; (C) arm-forearm DBP differences; (D) arm-ankle DBP differences

Table 1. Differences between the measurements

Parameters	Mean Values (mmHg)	Std. Deviation ($\pm$ mmHg)
Arm SBP	114.89	25.86
Forearm SBP	127.73	29.94
Ankle SBP	129.87	47.26
Arm DBP	67.80	16.23
Forearm DBP	77.69	19.99
Ankle DBP	68.71	19.59

For SBP measurements, There was no statistical difference in simultaneous arm measurements between the smoker and non-smoker group ($p=0.767$), (95% Confidence Interval(CI) 92.57 to 103.63 mmHg). For SBP measurements, There was no statistical difference in simultaneous forearm measurements between the smoker and non-smoker group ($p=0.946$), (95% CI 101.13 to 134.06 mmHg). For SBP measurements, There was no statistical difference in simultaneous ankle measurements between the smoker and non-smoker group ($p=0.836$), (95% CI 106.83 to 124.38 mmHg) respectively. For DBP measurements, There was no statistical difference in simultaneous arm measurements between the smoker and non-smoker group ($p=0.751$), (95% CI 82.86 to 91.09 mmHg). For DBP measurements, There was no statistical difference in simultaneous forearm measurements between the smoker and non-smoker group ($p=0.781$), (95% CI 60.82 to 83.17 mmHg). For SBP measurements, There was no statistical difference in simultaneous ankle measurements between the smoker and non-smoker group ($p=0.840$), (95% CI 55.56 to 65.50 mmHg) respectively (Table 2).

Table 2. Differences between the smokers and non-smokers groups

Parameters	Confidence Interval(CI) (mmHg)	P-value
Arm SBP	92.57 to 103.63	0.767*
Forearm SBP	101.13 to 134.06	0.946*
Ankle SBP	106.83 to 124.38	0.836*
Arm DBP	82.86 to 91.09	0.751*
Forearm DBP	60.82 to 83.17	0.781*
Ankle DBP	55.56 to 65.50	0.840*

Discussion

In the study, we found that the NIBP measurements of forearm and ankle, in patients who was under general anesthesia, were inconsistent with NIBP measurements of the arm. These alternative ABP measurement routes were not different in terms of efficiency, sensitivity in smokers and nonsmokers. In addition, the values we found in the limbs were consistent with previous studies showing similar measurements with lower values than those we measured in the ankle [1,4]. According to our study we can say that the alternative NIBP measurement regions can be used in smoker and non-smoker patients as an equally available.

The gold standard for the measurement of clinical ABP is always a mercury sphygmomanometer or a Korotkoff sound system, which is used in a health care facility [6]. In our study, it was measured by oscillometric techniques used in ABP anesthesia monitors. This method was first written in 1876 by the French physiologist Marey. With this methodology, ABP can also be measured without analysis of Korotkoff voices [6,7]. When the cuff pressure around an artery is reduced, SBP, DBP and mean arterial pressure (MAP) are determined. It has been shown that Korotkoff sound measurement method is the most suitable method by comparing different commercial ABP measurement types [6, 8, 9]. One of the difficulties with the oscillometric method is that the algorithms used to define SBP and DBP differ from one material to another. Due to these technical differences, it was vital that we did the measurements on the same manufacturer and the same monitor after calibration of all ABP measuring devices in our study.

The variations in ABP measurements were not unexpected. Generally, while SBP raised in more distal arteries, DBP was reduced, while MAP difference was stated to be reduced by only 1-2 mmHg between peripheral arteries [10]. In our study especially for the SBP, There was a statistical difference within the each smoker and non-smoker groups. It was similar to other studies with higher values of SBP in alternative measurement regions in the same patient.

Although this physiological conclusion is known, we determined to use SBP and DBP for comparison. In this arrangement, Walsh, M. et al. [11] proposed the use of SBP, not MAP in identifying. This recommendation was also based on the information that SBP was the most generally used parameter to define hypotension in patients [12], and studies in patients used changes in SBP as a definition of intraoperative hypotension [13]. However, in clinical anesthetic practice, the trend of ABP measurements is one of the essential components in directing intraoperative treatment. Therefore, it is vitally important to know that there are significant

differences in ABP measurement at different routes. But in our study, there was a statistical difference only within each group for SBP measurements.

Our study highlights the critical aspects of intraoperative hypotension. While most anesthesiologists consider intraoperative hypotension as a dynamic process [11], it should be taken into account that replacing the measurement site from the arm to another site, can be misleading. Also, it can be seen that consistency between arm-forearm and ankle measurements can be a guide for future measurement methods. It may also be essential to take into account future algorithms.

There is no consensus on how ABPs can best be perceived in terms of physiology and definition of hemodynamic variability in patients undergoing anesthesia [14,15]. At the same time, the frequency and duration of ABP measurement should be addressed. The explanation or conclusions of hemodynamic variability vary in different studies. It is understood that ABP values are continuously variable in intraoperative period. In this sense, it is important to obtain correct ABP values from alternative regions. That is why our study has completed the lack of study on this issue and we hope that the study will guide our colleagues.

Our study was limited to the fact that each ABP measurement was supposed to be an independent parameter and the number of measures was not equal for all participants and was based on the length of anesthesia and surgery. Almost a small sample size may be another limitation.

Conclusions

As a result, the forearm and ankle NIBP can be used as enough alternative to the widely accepted standard area for NIBP measurement. However, we think it would be beneficial to work with more detailed and larger patient groups.

Conflict of interest

The authors declare that there are no conflicts of interest.

Financial Disclosure

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Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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