

## Comparative evaluation of blood pressure monitoring devices

Avaliação comparativa dos equipamentos de aferição da pressão arterial

Erika Kaori Oka<sup>1</sup>, Liza Taveira Fleury<sup>1</sup>, Lucio Murilo dos Santos<sup>2</sup>, Mauro Santamaria<sup>3</sup>, Michelle Bianchi de Moraes<sup>3</sup>, Rodrigo Dias Nascimento<sup>3</sup>, Fernando Vagner Raldi<sup>3</sup>

1 – Institute of Science and Technology – UNESP – Univ Estadual Paulista – School of Dentistry – São José dos Campos – SP – Brazil.

2 – Institute of Science and Technology – UNESP – Univ Estadual Paulista – School of Dentistry – Department of Bioscience and Oral Diagnosis – São José dos Campos – SP – Brazil.

3 – Institute of Science and Technology – UNESP – Univ Estadual Paulista – School of Dentistry – Department of Diagnosis and Surgery – São José dos Campos – SP – Brazil.

### ABSTRACT

**Objective:** This study evaluated the agreement of blood pressure measurements obtained through different auscultatory and oscillometric automated/semi-automated monitors. **Material and Methods:** The blood pressure of 30 participants was evaluated by a single calibrated examiner. The measurements were carried out through either auscultatory monitor (mercury column or aneroid) or automated/semi-automated oscillometric pulse monitors. For each participant, 5 min rest was established by sitting on dental chair and the measurements were always carried out on the left arm, at the heart level. Three consecutive measurements were performed with the four monitors in each participant with a minimum time interval of five minutes between each measurement. All monitors were properly calibrated and certified by INMETRO. The results were submitted to intraclass correlation coefficient and Friedman's analysis of variance. **Results:** The measurements of systolic blood pressure for both auscultatory and oscillometric methods were similar. The measurements of diastolic blood pressure for auscultatory monitors were similar ( $p > 0.05$ ); as well as for oscillometric monitors ( $p > 0.05$ ). However, when auscultatory and oscillometric monitors were compared, there were statistically significant differences in diastolic blood pressure ( $p < 0.05$ ). **Conclusion:** It was verified a difference in the results between the auscultatory and oscillometric blood pressure monitors. The systolic blood pressure measurements exhibited similar correlations, while diastolic blood pressure measurements showed different correlations.

### KEYWORDS

Blood Pressure; Auscultatory; Oscillometric.

### RESUMO

**Objetivo:** Esse estudo avaliou a concordância da aferição da pressão arterial (PA) obtidas em diferentes equipamentos auscultatório e equipamentos digitais oscilométrico. **Material e Métodos:** A PA de 30 participantes foi avaliada por um único examinador calibrado. As aferições foram realizadas por meio de aparelhos auscultatório de coluna de mercúrio e aneróide e com equipamentos digital oscilométrico, semi automático e automático de pulso. Foi estabelecido para cada participante, repouso mínimo de cinco minutos permanecendo sentados na cadeira odontológica e as mensurações foram realizadas sempre no braço esquerdo, estando o mesmo apoiado ao nível do coração. Foram realizadas 3 mensurações consecutivas com os 4 aparelhos em cada participante com tempo mínimo de 5 minutos entre as aferições. Todos os aparelhos estavam devidamente calibrados e certificados pelo INMETRO. Com os resultados foi realizado coeficiente de correlação intraclass e a análise de variância de Friedman. **Resultados:** As medidas da pressão arterial sistólica (PAS) para o método auscultatório e para o oscilométrico foram semelhantes entre si. Para as medidas da pressão arterial diastólica (PAD), aparelhos auscultatórios foram semelhantes ( $p > 0,05$ ); aparelhos oscilométricos foram semelhantes entre si ( $p > 0,05$ ), porém quando comparados os modelos auscultatório com o oscilométrico ocorreu diferença estatisticamente significativa ( $p < 0,05$ ). **Conclusão:** Verificou-se diferença nos resultados entre os métodos auscultatórios e oscilométricos de medida da pressão arterial. Ocorreu uma correlação semelhante nas aferições obtidas para PAS e diferentes para PAD.

### PALAVRAS-CHAVE

Pressão Arterial; Auscultatório; Oscilométrico.

## INTRODUCTION

**B**lood pressure, defined as the direct relationship between cardiac output and peripheral resistance, is the pressure exerted by the blood against the artery walls. Which makes the blood goes from one area to another is the pressure difference. The normal mean blood pressure value is 120 x 80 mmHg. Notwithstanding, many physiologic, pathologic and pharmacologic factors influence and may alter the pressure, as follows: the gender (greater prevalence in males), patient's age (between 40 and 60 years), heredity, sedentary lifestyle, obesity, diet, diabetes, abusive use of caffeine and alcohol, smoking, stress, and some contraceptives and anti-inflammatory drugs [1].

It is mandatory that the dental professional know to measure the blood pressure as part of anamnesis and the initial examination of the patients to aid in formulating the comprehensive health of the patient and to define the diagnosis and treatment planning. The correct measurement of the blood pressure by the dentist is necessary to prescribe a drug, to choose the anesthetics and vasoconstrictor drug, and to care and plan the procedures. Moreover, in Dentistry, two other factors may influence in the blood pressure: the stress caused by the fear and the pain [2]. Thus, whether the patient will be submitted to a surgery or clinical examination, the blood pressure must be measured. The association of the stress with the vasoconstrictor drug in the anesthetic solutions may produce emergency alterations in the patient.

A patient with increased blood pressure (systolic blood pressure equal or greater than 140 mmHg and diastolic blood pressure equal or greater than 90 mmHg according to World Health Organization) is at greater risks during clinical dental practice. In a case of poorly-controlled hypertension, dental surgery may show either profuse bleeding or hemorrhages. Considering the greater risk of hemorrhage of

a hypertensive patient, the dentist faces the difficulty of choosing the anesthetics. The use of local anesthetics without vasoconstrictor drug causes vasodilation, increasing the anesthetics absorption and toxicity and decreasing the duration and effectiveness of the local anesthetic action, increasing the risk of hemorrhages. On the other hand, the use of local anesthetics with vasoconstrictor drugs provokes a delay in the anesthetic absorption, but it induces the blood pressure increasing [3]. Accordingly, it is of extreme importance that the dentist knows the blood pressure of a patient and in case of hypertension, to know whether it is or is not controlled.

Blood pressure can be measured through many methods: mechanical mercury sphygmomanometer, mechanical aneroid sphygmomanometer and digital sphygmomanometer. Because this is an important measurement in dental practice, the knowledge of the effectiveness and reliability of the methods of blood pressure measurement is necessary. Therefore, this study aimed to evaluate the effectiveness of four blood pressure monitors frequently used in dental practice.

## MATERIAL & METHODS

### *Study subjects*

This study was submitted and approved by the Ethical Committee in Research of the institution under protocol number 049/2009-PH/CEP. All participants read and signed a Free and Clarified Consent Form. The study sample comprised thirty individuals who sought for treatment at the clinics of the Discipline of Surgery and Oral and Maxillofacial Trauma of the Science and Technology Institute, São Paulo State University (São José dos Campos/SP, Brazil), who were instructed about the study purpose on evaluating and comparing the results obtained from the measurements of the blood pressure through different methods during the anamnesis.

### **Sample characteristics**

The selection of patients followed the criteria below:

#### **Inclusion criteria:**

- 1 – Signing of the Free and Clarified Consent Form, according to the Resolution CNS number 196/96,
- 2 – Healthy patients who needed oral surgery
- 3 – Patients aged above 18 years,
- 4 – Irrespective of race,
- 5 – Irrespective of gender.

#### **Exclusion criteria:**

- 1 – Patients using any drug that may interfere in hemodynamics.

#### **Sample size calculation**

In this study, 30 patients comprised the sample considering the pre-established inclusion and exclusion criteria. To reach this number, a difference of 2 mmHg (clinically relevant) among groups was considered for the primary variable. Considering a power of 80%,  $\alpha = 0.05$  and an expected standard-deviation of 1 mmHg, a sample of 23 individual per group would be necessary for applying the analysis of variance. In this study, the sample size of 30 participants submitted to the blood pressure measurement through all monitors (which resulted in 30 participants per group), had a power greater than 80% to detect a difference of 2 mmHg of blood pressure among the monitors.

#### **Clinical procedures**

The blood pressure was measured through four different monitor types: mercury sphygmomanometer with manual arterial cuff (Unitec) and with the aid of stethoscope; aneroid sphygmomanometer with a dial and manual arterial cuff (BD), and with the aid of stethoscope; semi-automated digital sphygmomanometer and manual arterial

cuff (Techline); and automated digital pulse sphygmomanometer (Techline). All devices were commonly found in Brazilian dental market and were certified and approved by the Brazilian Institute of Metrology, Standardization and Industrial Quality (INMETRO). All monitors were previously calibrated for the study.

The measurements were initiated through mercury sphygmomanometer (monitor 1), followed by aneroid sphygmomanometer with dial (monitor 2), semi-automated digital (monitor 3), automated digital pulse sphygmomanometer (monitor 4), always in this order and with a constant time interval among them.

For the measurements through monitors 1 and 2, the cuff was placed around the medium third of the left arm, directly in contact with the skin and the arm was maintained at the heart level; the bulb was consecutively pressed to inflate the cuff until the mercury column or manometer reached 200 mmHg.

The measurements through monitors 3 and 4 were executed according the manufacturer's instructions.

All data were recorded on specific sheets.

#### **Methods of obtaining the data**

The reading of the blood pressure of all patients was performed by a single examiner previously calibrated by Kappa coefficient through three consecutive measurements of each monitor, resulting in 12 individual readings. The collection of data occurred in an office previously selected providing a quiet environment, always at the morning and without physical exercises prior to the blood pressure measurement.

#### **Procedure**

For each participant, a minimum rest period of five minutes was established by sitting on the dental chair. The measurements were carried out always on the left arm, at the heart level, with a minimum time period of 5

min among the measurement, according with the guidelines.

### Data analysis

To measure the reliability and homogeneity of the measures, intraclass correlation coefficient was applied. The simple mean of three systolic and diastolic blood pressure measurements was performed for statistical analysis. Shapiro-Wilk test was applied for the evaluation of data distribution. Next, one-way ANOVA for repeated measures was applied to evaluate the difference among groups, with level of significance of 5%.

## RESULTS

Prior to the measurements, the examiner was calibrated. Kappa test demonstrated an agreement of 93% of the measurements, resulting in good calibration. Nineteen females and 11 males aged from 25 and 58 years were treated. After the blood pressure measurements of each patient through all monitors, intraclass correlation coefficient was applied. For this study, 10 patients for each method of systolic and diastolic measurements were considered. Intraclass correlation coefficient was used to test the sample agreement for continue data (Table 1).

**Table 1** - Intraclass correlation coefficient. (monitor 1) mercury sphygmomanometer; (monitor 2) aneroid sphygmomanometer with dial; (monitor 3) semi-automated digital; and (monitor 4) automated digital pulse sphygmomanometer

Monitor	Correlation coefficient		Correlation coefficient	
	Systolic		Diastolic	
Monitor 1	0.97	p < 0.00001	0.9442	p < 0.00001
Monitor 2	0.9894	p < 0.00001	0.8338	p < 0.00001
Monitor 3	0.7693	p < 0.00001	0.6488	p = 0.0124
Monitor 4	0.8932	p = 0.00002	0.9047	p = 0.00001

It could be observed that only for the data obtained in method 3 diastolic measurements a medium to good agreement (p = 0.0124). The other results showed excellent agreement (p ≤ 0.00001).

**Table 2** - Means and standard deviations (mmHg) of each monitor used for the 30 participants

	Monitor 1	Monitor 2	Monitor 3	Monitor 4
Systolic	114.8 ± 9.7 a	114.8 ± 9.7 a	114.0 ± 11.3 a	113.1 ± 9.1 a
Diastolic	75.6 ± 8.9 a	75.5 ± 9.0 a	68.9 ± 9.8 A	69.4 ± 8.2 A

Aa – Statistically significant difference among the methods – (One way analysis of variance for repeated measures - ANOVA).

When the means of the four monitors were compared, the systolic measurements did not show statistically significant differences (p > 0.05). However, the diastolic measurements showed statistically lower means for methods 3 and 4 than those for methods 1 and 2 (p < 0.05). The differences between groups 1 and 2 and between groups 3 and 4 did not show statistically significant differences.

## DISCUSSION

Generally, mercury sphygmomanometer is the gold standard method for the indirect blood pressure measurements because it is considered the most reliable method [4]. Notwithstanding, this present study advocated the comparison between aneroid sphygmomanometer and digital sphygmomanometer because these are the methods most used for blood pressure measurement in dental practice.

In this study, the comparison between aneroid sphygmomanometer and digital sphygmomanometer exhibited an agreement for systolic measurements, while the diastolic measurements through digital sphygmomanometer were significantly lower, agreeing with Mano et al. [5], who compared the results of blood pressure measurement through digital monitor and Lithell et al. [6] who conducted a study comparing a semi-automated with mercury sphygmomanometer.

Still regarding the comparison of blood pressure measurements performed through auscultatory and oscillometric methods, Keavney et al. [7] verified similar measurements, which disagree with this present study.

The study of Basso et al. [8] found an excellent agreement for systolic and good agreement for diastolic blood pressure measurements, among those obtained by the two methods. Rego Filho et al. [9], in a study on the accuracy of the oscillometric method compared with the auscultatory method through mercury sphygmomanometer in children found greater correlation for systolic than diastolic blood pressure. This present study corroborates these findings because the systolic values were similar and the diastolic values different.

The study conducted by Galvão et al. [4] is in agreement with the results of this present research for the systolic blood pressure; however, diastolic blood pressure measurements showed relatively greater values for oscillometric method.

This finding may be related to the fact that the values obtained by the oscillometric digital monitors are estimates of systolic and diastolic blood pressure measurements (mean blood pressure), while auscultatory monitors provide absolute values of blood pressure. According to Cerulli M. [10], the oscillometric method may provide significant different measurements without they are incorrect. Thus, when the blood pressure measurement is performed through the oscillometric method, many measurements should be performed to obtain accurate values.

The rationale behind this difference would be the alteration of the muscle tone because of patients' anxiety at the moment of the measurement. According to the handbook of the blood pressure monitors, severe alterations in both systolic and diastolic and pulse measurements may occur whether the patient is not completely relaxed. This situation may be complicated by the physiologic stress of the measurement itself, so that many measurements should be performed by the digital monitor to assure reliability and further studies are still necessary [11].

## CONCLUSION

It was verified a difference in the results between the auscultatory and oscillometric blood pressure monitors. The systolic blood pressure measurements exhibited similar correlations, while diastolic blood pressure measurements showed different correlations. Further studies are necessary.

## REFERENCES

1. Pierin AMG, Mion D Jr, Fukushima JT, Pinto AR, Kaminaga MM. The profile of hypertensive patients related to awareness and level of hypertension. *Rev Esc Enf USP*. 2011;35(1):11-8.
2. Oliveira PC, Barbosa DZ, Souza HJ, Batista JD, Ranali J, Costa MDMA, Azevedo PC. Evaluation of anxiety and pain levels in patients with endodontic urgency and influence in cardiovascular parameters. *Cienc Odontol Bras*. 2007 out/dez;10(4):70-5.
3. Nascimento EM, Santos MF, Martins VM, Cavalcanti AL, Menezes VA, Garcia AFG. Approach to dental patients with hypertension – an intervention study. *RFO*. 2011 Jan-Apr;16(1):30-5
4. Galvão EL, Batista JG, Figueiredo FL, Pereira WF, Ferreira AE. Comparação entre os métodos auscultatório e oscilométrico de determinação da pressão arterial. *Revista Espaço para a Saúde, Londrina*. 2009;10(2):27-33.
5. Mano GMP, Souza VF, Pierin AMG, Lima JC, Ignes EC, Ortega KC, et al. Assessment of the Dixtal DX-2710 automated oscillometric device for blood pressure measurement with the validation protocols of the British Hypertension Society (BHS) and the Association for the Advancement of Medical Instrumentation (AAMI). *Arq Bras Cardiol*. 2002;79(6):601-10.
6. Lithell H, Berglund L. Validation of an oscillometric blood pressure measuring device: a substudy of the HOT study. *Blood pressure*. 1998;7(3):149- 52.
7. Keavney B, Bird R, Caiazza A, Casadei B, Conway J. Measurement of blood pressure using the auscultatory and oscillometric methods in the same cuff deflation: validation and field trial of the A&D TM2421 monitor. *J Hum Hypertens*. 2000;14(9):573- 9.
8. Basso MFM, Loffredo LCM. Estudo comparativo da pressão arterial sistêmica obtida por dois métodos distintos. *Ver Ciênc Farm Básica Apl*. 2006;27(1):79- 82.
9. Rego Filho EA, Mello SFR, Silva CRSE, Vituri DW, Bazoni E, Gordan LN. Accuracy of the oscillometric method to measure blood pressure in children. *J Pediatr (Rio J)*. 1999;75(2):91-6.
10. Cerulli M. O método oscilométrico de medição da pressão arterial. *Hipertensão*. 2000;3(3):110-5.
11. Danieleto CF, Cordeiro RF, Iwaki LCV, Iwaki Filho L, Farah GJ. Avaliação comparativa entre aparelhos de pressão arterial e entre glicosímetros de diferentes marcas. *Pesq Bras Odontoped Clin Integr, João Pessoa*. 2011 Out/Dez;11(4):525-31.

### Michelle Bianchi Moraes (Corresponding address)

Av. Eng. Francisco José Longo, nº 777, Jardim São Dimas  
12245-000 - São José dos Campos – SP – Brazil.

Date submitted: 2014 Jun 02

Accept submission: 2014 Oct 20