Journal of Bioelectromagnetism
Vol. 14, No.1, pp.22-26, 2012

Magnetic *vs*. Sphygmomanometry Cardiac Pressure

T Cordova[a,c,*], F Gomez[a], L Romero[b], MA Hernadez[b], CR Contreras[c],
S Solorio[b], M Sosa[a] and J. Bernal[b]
[a]Dept. Ingeniería Física-DCI, Universidad de Guanajuato campus Leon, GTO, Mexico.
[b]UMAE, Clínica T1-León, Instituto Mexicano del Seguro Social, GTO, México.
[c]F. de Ingenieria en Computacion y Electronica, Universidad De La Salle Bajio, Leon GTO, México

*Correspondence: Cordova T, Dept. Ingeniería Física-DCI, Universidad de Guanajuato campus Leon, GTO, Mexico.
E-mail: theo@fisica.ugto.mx, phone 52(477) 788-5100, exts: Fax 8410, Of. 8454, Lab. 8475.

Abstract. A comparative study carried out in humans with a digital manual sphygmomanometer *vs*. magneto mechanical cardiac pressure device is presented. In this study 38 healthy subject were enrolled. This device includes a small magnet and a magnetometer and it is able to record graphic behavior identical to cardiac catheter technique, with the versatility to perform signal acquisition at skin level. The study was performed in IMSS hospital, where 38 patients were enrolled in order to be evaluated with both techniques. A high correlations was found between these techniques, where Systolic blood pressure, sleeping was around r = 0.91 with p – values of 0.0001, and Lying systolic blood pressure around r = 0.14 with p – values of 0.3381. Such, this new methodology may be an alternative to have this device in ER-hospital, Intensive therapy rooms and it could prevent catheterize surgical intervention. This is a cardiac signal modality at skin level, with a portable device.

Keywords: blood vessel, biomagnetic signal, magnetic marker.

1. Introduction

One of the principal clinical vital signs is the evaluation a monitoring of blood pressure (BP), which ones is defined as the force exerted by circulating blood on the walls of the body's arteries and constitutes. Arterial pressure is most commonly measured via a sphygmomanometer device [Pannier *et al*., 2002]. For each heartbeat, BP varies between systolic and diastolic pressures. The systolic pressure is the peak pressure in the arteries, which occurs early in the cardiac cycle when the ventricles are contracting. Diastolic BP is the minimum pressure in the arteries, and occurs late in the cardiac cycle when the ventricles are filled with blood.

An invasive technique for assessment the BP consists of a procedure in which it is measured inside the blood vessel using an intra-arterial catheter connected to a sensitive pressure transducer. Although invasive, this procedure is considered the gold standard technique for measuring arterial pressure because it is more accurate than Sphygmomanometry [Kurtz *et al*., 2005] and can be used to detect rapid variations in BP.

Recently, a patenting register was requested of a magnetometer device development in our laboratory, this is a magnetomechanical cardiac pressure associated with heart activity. This single device is noninvasive, capable of recording arterial and vein behavior.

In this paper the validation of a device for magnetomechanical cardiac pressure (MMCP) is presented, this evaluation was performed in terms of repeatability and reproducibility, considering the sphygmomanometer as a reference method on the analysis of correlation between the MMCP and the conventional methods.

2. Methods

The arterial blood pressure measurements were performed with the patient at rest in a quiet area without the presence of magnetic stimuli that could alter SNR reason. With a sphygmomanometer appropriate to the patient's condition (covering 80% of the circumference of the patient's arm, bringing the manometer to 30 mmHg than expected, based on noise and fluctuations Korotcoff gauge for determining systolic pressure and verify using the index and middle fingers of the patient's pulse as the pulse of the digital arteries can cause substantial errors in the sampling [Vazquez *et al*., 20009]. Each measurement was performed at the patient sitting and recumbent; see Fig 1, [Maldonado-Morel *et al*., 2008].

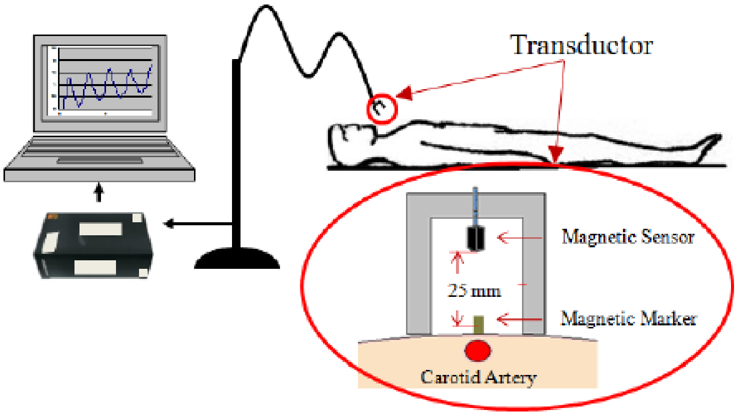

Figure 1: MMPC's Schematic setup.

The MMCP include a magnetoresitor sensor which is fixed inside maximum of a frame of capital "U" inverted; this is done in order to control distance source-sensor and avoid touching to the patient and also avoid increasing the human artifacts. The magnetotactic of a cylindrical permanent magnet is interrupted when it is attached to patient skin just above the blood vase, see Fig. 1, then, magnetic variations are recorded and the wave behavior is identical to catheterization techniques measurement, see Fig. 2, which is gold standard technique in this evaluation. Such, the MMCP device's base was placed on the neck of the subject of study, without putting pressure on the skin to record the magnetic field emitted by the magnetic dipole, equation (1). This is to certify that there were no ferromagnetic objects near the device that could change the reading. Records obtained were stored in a computer using a software program LabVIEW

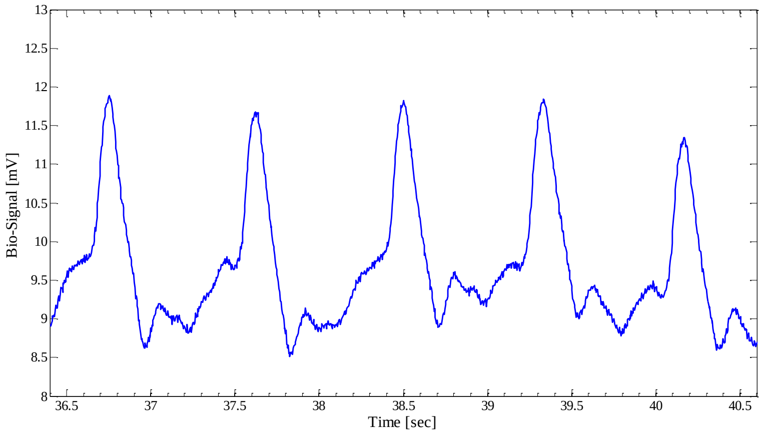

Figure 2: Bio signal recorded on carotid artery of a patient with the *MMCP* device.

$$\vec{B}(r) = \frac{\mu_0}{4\pi}\left[\frac{3\vec{r}\left(\vec{r}\cdot\vec{m}\right)}{r^5} - \frac{\vec{r}}{r^3}\right]. \tag{1}$$

Finally, to ensure blinding, another working group was unaware of the hypotheses, the catching of the database and statistical analysis of the results of measurements with different devices. To analyze the repeatability of the MMCP device, the measurements were carried out under the same conditions, patient were instructed to follow a particular protocol and the MMCP device, and the digital manual sphygmomanometer always were used and, operated by the same technicians, as long as patients were subjected to measurements within of time not exceeding 10 minutes between each measurement. To analyze the reproducibility of the MP, the measurements obtained by this device were compared with those obtained by the two standard diagnostic methods, [Chobanian *et al*., 2003], [rosei *et al*., 2008].

The blood pressure measurement was performed in 38 subjects with a criteria of inclusion that taking into account that they have to be classified as healthy adults of both genders, between 20 and 50 years of age without the presence of smoking, no history of chronic and degenerative diseases accepted participate in the study with informed consent, see Table 1.

Table 1: Characteristics of the Population enrolled in this study.

Subjects	Mean	Standard deviation
Age	30.06 y	± 6.82
Weight	74.54 kg	± 11.56
Height	167.55 m	± 9.81
BMI (Body Mass Index)	26.88 kg/m^2	± 3.72

2.1 Statistical Analysis

Exploratory analysis was conducted of all numerical variables by bias and kurtosis, using descriptive statistics to determine the distribution curve: the variables are described according to their nature, continued in accordance with the mean ± standard deviation, if normally distributed variables are ordinal and binary categories are expressed as percentages. The relationship between measures of *MMCP* and the standard procedure was obtained by Pearson correlation coefficient, considering the significant values of pa less than 5 %. See Table 2.

3. Results

Taking into account the following criteria: healthy adults of both genders, between 20 and 50 years of age, of whom 29 were men and 9 women in the fourth decade of life, with the presence of overweight, without the presence of smoking history, no history of chronic degenerative diseases and who chose to participate in the study of how voluntary and signed informed consent before the study. We found the presence of a strong correlation between systolic blood pressure taken with the digital sphygmomanometer and stroke volume yielded by the PPM with a confidence interval of 0823 -0951 with a p value of 0.0001, see Table 2 and Figure 3

Table 2. Analyzed results from the measurements of blood pressure and the values recorded with the *P*-values

Variables comparison digital manual sphygmomanometer *vs.* MMCP	correlation coefficient	confidence interval 95 %	*P* Value	Precision
Diastolic blood diastolic pressure cuff to bed	0.40		0.0100	
Systolic blood pressure cuff to bed	0.80	0.64 – 0.89	0.0001	0.80
Diastolic blood pressure, sleeping	0.29	0.34 – 0.56	0.0791	0.29
Systolic blood pressure, sleeping	0.91	0.82 – 0.95	0.0001	0.91
Lying systolic blood pressure	0.14	0.18 – 0.44	0.3380	0.37
Systolic blood pressure cuff	0.51	0.25 – 0.31	0.0010	0.51
Diastolic blood pressure	0.29	0.03 – 0.56	0.0770	0.29
Systolic blood pressure	0.63	0.36 – 0.79	0.0001	0.63

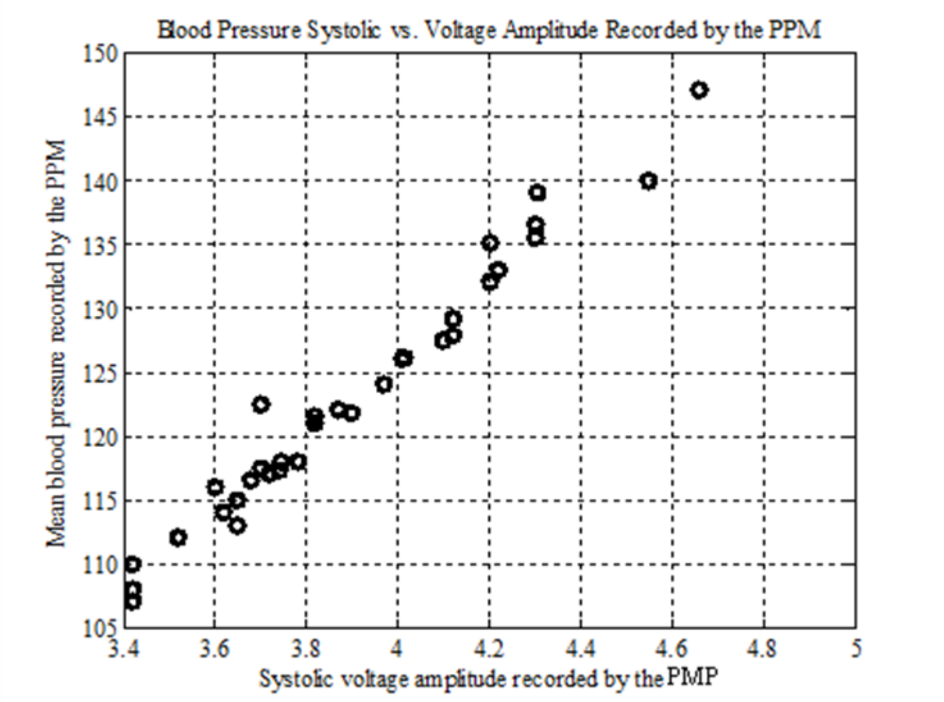

Figure 3:. Relationship between blood pressure and
the average recorded systolic voltage amplitude recorded by the *MMCP* device.

4. Discussion and Conclusions

Systemic hypertension is one of the most important risk factors in the development of cardiovascular and cerebrovascular diseases [Menotti *et al*., 2009]. The incidence of acute myocardial infarction, stroke, heart failure and renal failure increases with high blood pressure. Under normal conditions, factors that determine blood pressure remain in harmonious conjunction, controlled by self-regulatory systems that determine arteriolar tone, intravascular blood volume and its distribution [Mansencal *et al*., 2007]. The clinical measurement of blood pressure established by conventional methods, it is widely accepted because it is a useful, simple, affordable, accessible and noninvasive. However, often incurs erroneous readings of blood pressure depending on the operator, as shown in the study where blood pressure recording with manual technique depended entirely on the operator and got much less precise compared with the records obtained by digital manual sphygmomanometer and *MMCP* device, usually by systematic errors of the art at the time of registration of blood pressure, in addition to the log is not continuously obtained through conventional methods.

The *MMCP* continues to be dependent on certain variables that you sign up for blood pressure, but shows that once established these conditions; there is a close correlation between the measurement of systemic blood pressure between digital manual sphygmomanometer and the *MMCP* results

This new device is a noninvasive device, in healthy volunteers is able to record the extent of venous and arterial pulse continuously measured using a painless method, which does not create any discomfort to the individual during the study and where there were no complications in procedures performed in healthy volunteers. Results from statistical analysis to analyze measurements on volunteer patients, shows that the relationship between changes in blood pressure measured by standard methods compared to the *MMCP* is considered a reliable tool for measuring blood pressure in healthy patients who volunteered in the study, being able to play through magnetism, in a reliable and ergonomic way for both the subject and the director of the study.

Acknowledgements

Authors want to thank DAIP under grant number 000017/10, FESE 2010 and UDLSBajio 2010, for their partial support in this study.

References

Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo jl Jr, et al. Joint national committee on prevention, detection, evaluation, and treatment of high blood pressure. National heart, lung and blood institute; national high pressure education program coordinating committee. Seventh report of the Joint national committee on prevention, detection, evaluation and treatment of high blood pressure. J. Hypertens, 42:1206-52, 2003.

Kurtz TW, Griffin KA, Bidani AK, Davisson RL, Hall JE. Recommendations for blood pressure measurement in animals: summary of an AHA scientific statement from the Council on High Blood Pressure Research, Professional and Public Education Subcommittee. Arteriosclerosis, thrombosis, and vascular biolog, 25(3):478-9, 2005.

Maldonado-Moreles M.A., Cordova-Fraga T, Cano M E, Solorio-Meza Sergio E and Sosa M A. Registration of intravascular pressure Curves: Magneto-Mechanical Evaluation. Medical Physics, AIP Conf. Proc1032 (1): 302-305, USA.Editors: Gerardo Herrera Corral and Luis Manuel Montaño Zentina, 2008.

Mansencal N, d'Allonnes LR, Beauchet A, Fabre S, Digne F, Farcto JC, et al. Reliability of echocardiography for hemodynamic assessment of end stage heart failure. Am J Cardiol, 100:998-1001, 2007.

Menotti A, Lanti M, Angeletti M, Botta G, Cirillo M, Laurenzi M, et al. Twenty-year cardiovascular and all-cause motality trends and changes in cardiovascular risk factors in Gubbio, Italy: the role of blood pressure changes. J. Hypertens, 27:266-74, 2009.

Pannier BM, Avolio AP, Hoeks A, Mancia G, Takazawa K. Methods and devices for measuring arterial compliance in humans. *American Journal of Hypertension*, 15(8):743-75, 2002.

Rosei EA, de Simone G, Mureddu GF, Trimarco B, Verdecchia P, Volpe M, et al. Commissione congiunta societá italiana dell'lpertensione arteriosa; societá italiana di cardiologia; associazione nazionale medici cardilogi ospedalieri hypertensive heart disease: diagnostic and therapeutic guidelines. G Ital cardiol (Rome), 9:427-54, 2008.

Vazquez JA, Savelli C, Terán R. Técnica de medición de la presión arterial utilizada por enfermeras auxiliares del hospital universitario de Caracas. RFM. [online]. Mar. 2001, vol. 24, no.1, p. 80-87. ISSN 0798-0469.