National Journal of Physiology, Pharmacy and Pharmacology

RESEARCH ARTICLE

A cross-sectional analytical study on the influence of age in the precision and accuracy of non-invasive blood pressure recording compared to invasive intra-arterial pressure recording

Ramanathan Sobana[1], Srinivasan Parthasarathy[2], Trakroo Madanmohan[1], Balasubramaniam Amirthaganesh[3], Krishnan Jaiganesh[1]

[1]Department of Physiology, Mahatma Gandhi Medical College and Research Institute, Puducherry, India, [2]Department of Anaesthesiology, Mahatma Gandhi Medical College and Research Institute, Puducherry, India, [3]Department of Cardiology, Mahatma Gandhi Medical College and Research Institute, Puducherry, India

Correspondence to: Srinivasan Parthasarathy, E-mail: painfreepartha@gmail.com

Received: October 02, 2017; **Accepted:** October 20, 2017

ABSTRACT

Background: Even after 115 years after the invention of Riva-Rocci Sphygmomanometer, the technique which shows the maximal accuracy of blood pressure (BP) measurement remains elusive. Currently, non-invasive BP (NIBP) recording is commonly done worldwide. Yet, intra-arterial pressure (IAP) recording gives a beat to beat accurate recording of one's BP. **Aims and Objectives:** The aims of this study are as follows: (1) To compare NIBP with IAP in various age groups and (2) to study the influence of age in the accuracy of NIBP recording. **Materials and Methods:** A total of 98 patients aged 30–75 years posted for a coronary angiogram (CAG) were recruited for the study and divided into 3 groups based on age (Group I 30–45, Group II 46–60, and Group III 61–75). Two sets of NIBP and corresponding IAP (radial and aortic arterial pressures) were recorded during CAG. Paired *t*-test to compare the NIBP with corresponding IAP and ANOVA with *post-hoc* Bonferroni to check the influence of age with the accuracy of recording were done. **Results:** NIBP differed significantly with the corresponding IAP when analyzed by paired *t*-test ($P < 0.0001$). Multiple comparisons between three age groups and the pressure difference by ANOVA were done. Age Groups I and III (30–45 years and 61–75 years) both systolic NIBPI versus radial artery pressure ($P = 0.013$) as well as diastolic NIBP II versus arterial blood pressure (ABP) ($P = 0.053$) pressure comparison were widely different. Age Groups II (46–60 years) and III (61–70 years) varied in the diastolic NIBPII versus ABP comparison with $P = 0.050$. The results thus indicate that there is discrepancy of manual BP versus IAP with an increasing trend with the advancement of age. **Conclusion:** Thus, the results indicate that there is a discrepancy of NIBP versus IAP with NIBP showing higher values which widens with advancing age.

KEY WORDS: Non-invasive Blood Pressure; Intra-arterial Pressure; Blood Pressure Recording; Aging

Access this article online	
Website: www.njppp.com	Quick Response code
DOI: 10.5455/ijmsph.2018.1039720102017	

INTRODUCTION

Across the globe, arterial blood pressure (ABP) measurement is the widely assessed diagnostic tool in the treatment, planning, and follow-up of hypertensives. Intra ABP (IABP) is the gold standard for measurement of BP as it gives accurate beat to beat information.[1] Since it is invasive and

needs expertise, non-invasive BP (NIBP) is recorded in day-to-day practice. Even after 115 years after its invention, the sphygmomanometer by Riva-Rocci continues to be familiar among practitioners. As cuff pressure is an indirect measurement of BP, age, anthropometric, biochemical, and hemodynamic factors influence the precision of these pressure recordings.[2,3] If the BP measurement is not accurate, we might be unnecessarily prescribing antihypertensive for normotensives and inadvertent inotropes in sick patients.[4,5] Among the various factors, aging influences the accuracy of BP recording significantly but extents to which it alters is the area to be explored. Hence, we intended to study the influence of age in the accuracy of BP recordings by comparing NIBP with the IAP.

Objectives

The objectives of this study are as follows:

- To compare NIBP with IAP in various age groups.
- To study the influence of age in the accuracy of NIBP recording.

MATERIALS AND METHODS

It is an observational cross-sectional study conducted in collaboration with the Department of Cardiology after obtaining clearance from the Institutional Human Ethical Committee - 2016/03/06

Inclusion Criteria

A total of 98 patients of both sexes aged between 30 and 75 years posted for a coronary angiogram (CAG) were recruited after obtaining written informed consent. Subjects were divided into 3 groups based on the age.

- Group I: 30–45 years.
- Group II: 46–60 years.
- Group III: 61–75 years.

Exclusion Criteria

The following criteria were excluded from the study:

- Subjects on vasoactive drugs.
- Coexisting peripheral arterial diseases.
- Arrhythmias.

Out of the 98 patients recruited, 2 were excluded before CAG as they declined and 6 became critically ill during the procedure. Hence, data of 90 patients (58 men and 32 women) were collected [Figure 1].

The protocol adhered for data collection during CAG is summarized below. Radial artery was cannulated with aseptic precautions to perform CAG. To prevent thrombosis and spasm, intra-arterial cocktail comprising of 3000–5000 units of unfractionated heparin, 2.5–5 mg of diltiazem,

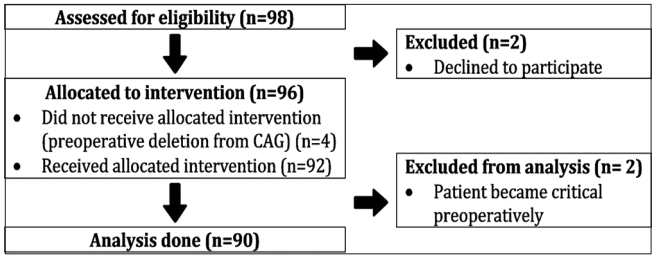

Figure 1: Consort chart

and 100–200 µg of nitro-glycerine was administered. The administration of this drug mixture is a routine in our institute for all patients undergoing an angiogram. A period of 5 min was allowed for hemodynamic stabilization.

After necessary calibrations of the pressure line, when the catheter guided by radial sheath was in the radial artery, the radial artery pressure (RBP) was recorded. Simultaneously, cuff pressure (NIBP I) was recorded using appropriate cuff as per AHA JNC 2015 guidelines for BP measurement.[6] The diagnostic catheter which was introduced through the sheath was advanced to the aortic root. When catheter reached aortic root, intra-aortic pressure (ABP) and simultaneous cuff pressure (NIBP II) are recorded. The two NIBP values were compared with the corresponding invasive IAP recordings (RBP and ABP) and analysis done for the degree of significance. If there was significant variation between the NIBP and IAP measurements, the level of discrepancy was compared between the corresponding pairs of three age groups.

Statistical Analysis

The recorded data were analyzed in three steps. Initially, the mean systolic, diastolic NIBP, and corresponding IAP were estimated. NIBP and corresponding IAP were compared by paired sample *t*-test. The differences between the NIBP versus IAPs were analyzed between the three age groups by ANOVA and *post-hoc* by Bonferroni.

RESULTS

Of 98 subjects recruited, 8 were excluded, and hence, data were collected for 90 subjects (58 men and 32 women). Peripheral arterial and central aortic pressures were recorded by non-invasive and invasive methods. The NIBP recorded by cuff method and IAP noted from the monitor when the catheter is *in situ* at radial artery and aorta. The mean value of peripheral and central BP by direct and indirect methods (NIBP I, NIBP II, RBP, and ABP) was calculated, respectively. The peripheral and central NIBPs were compared to the corresponding IAP by paired sample *t*-test. NIBP I was compared to radial pressure, and NIBP II compared to aortic pressure. There were four pairs of BP for comparison, i.e., systolic and diastolic NIBP I versus radial BP and systolic and diastolic NIBP II versus aortic BP. There

is statistically significant difference between NIBP and IAP in all four pairs ($P < 0.001$) [Figure 2 and Table 1].

The extent of discrepancy between the indirect and direct BP was compared between three age groups. Multiple comparisons of the NIBP versus IAP pressure difference between three age groups were done by ANOVA. Radial cuff pressure differed from the IAP, and this difference was marked between the Groups I and III (30–45 years and 61–75 years). Both Systolic NIBPI versus RBP ($P = 0.013$) and diastolic NIBP I versus RBP ($P = 0.050$) pressure comparison showed wide differences between age Groups I and III. The mean differences in the three age groups were compared. Age Group II (46–60 years) and III (61–70 years) varied in the diastolic NIBP II versus ABP comparison widely but only with a $P = 0.053$ [Table 2]. A scatter plot with age and NIBP versus IAP depicts a positive correlation of age with the pressure difference. Hence, as the age advances, the discrepancy increased [Figure 3].

DISCUSSION

Analysis of our results showed that both systolic and diastolic NIBPs differed markedly compared to IAP. Comparing the difference among various age groups, the elderly (Group III aged 61–75 years) showed more discrepancy than the other groups ($P < 0.01$). The difference in the BP recording was more inaccurate in Group III compared to the other groups who were younger. We can conclude that, with the advancement of age, NIBP recording becomes markedly deviated from the IAP which is considered as the gold standard. This finding is in concordance with an earlier study by Kayrak *et al*.[7] He reported that deviation in DBP and SBP recording was augmented in the elderly above 60 years with comorbidities. Prospective Investigation of Vasculature in Uppsala Seniors by Lind *et al*. on geriatric population observed discrepancy in the BP recordings proportional to the markers of obesity such as raised BMI and lipid level.[8] Prospective Cardiovascular Munster[9] study conducted in middle-aged men reports a correlation of metabolic syndrome with BP values. Clark *et al*. compared direct and indirect BP measurements.[10] In contrary to our observation, he concluded that the discrepancy of indirect BP recording is attributed to inappropriate cuff selection. However, as our study was done taking stringent AHA JNC 2015 recommendations while recording and choosing appropriate cuff, hence this is insignificant in our study. Mary J. Roman in his strong heart study compared the central and brachial pressures relation to various predictor outcomes, age, BMI, lipid levels, and the presence of comorbidities. This study concluded that the changes in age, diabetes, and serum creatinine levels were very strongly related to outcome.[11]

Framingham's cohort study on 30-year follow-up of cardiovascular disease (CVD) risk stratification stressed the importance of continuous graded relation of SBP to the rate of CVD outcome at all ages. He recommended that even trivial BP difference within high normal range must not be underestimated. The results of both the present study and the Framingham analysis by Franklin *et al*. are consistent with an age-related shift in the accuracy of BP monitoring.[12] The Multiple Risk Factor Intervention Trial on 10-year follow-up of coronary heart disease risk in the age group 35–57 years observed risk of age-related CVD risk consistent with BP measurements.[13] Few other studies conducted in

Table 1: Comparison of NIBP and IAP

Comparison of	Mean difference±SD	*P*
Systolic NIBP I versus RBP	12.53±15.6230	0.000
Diastolic NIBP I versus RBP	10.44±15.6230	0.000
Systolic NIBP II versus ABP	6.69±15.1820	0.018
Diastolic NIBP II versus ABP	4.812±6.737	0.000

SD: Standard deviation, IAP: Intra-arterial pressure, NIBP: Non-invasive blood pressure, RBP: Radial artery pressure, ABP: Arterial blood pressure

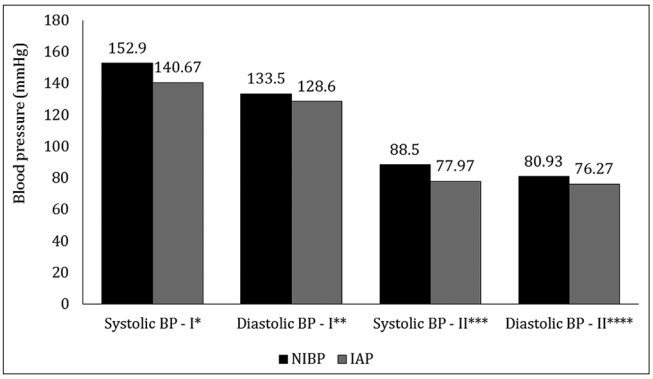

Figure 2: Mean non-invasive blood pressure (NIBP) and intra-arterial pressures. *Systolic BP - I: Systolic NIBP I versus radial artery pressure (RBP), **Diastolic BP - I: Diastolic NIBP I versus RBP; *** Systolic BP - II: Systolic NIBP II versus arterial blood pressure (ABP), **** Diastolic BP - II: Diastolic NIBP II versus ABP

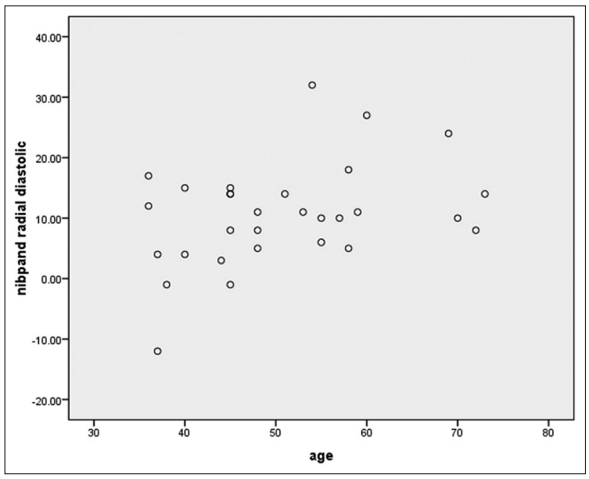

Figure 3: Age versus non-invasive blood pressure and diastolic pressure

Table 2: Multiple comparisons of all the four variables by ANOVA

Dependent variable	(I) age group (years)	(J) age group (years)	Mean difference (I-J)	Standard error	Significant
Systolic NIBP I versus RBP	30–45	46–60	−2.774	6.503	1.000
		61–75	1.083	9.544	0.013*
	46–60	30–45	2.774	6.503	1.000
		61–75	3.857	9.372	1.000
	61–75	30–45	−1.083	9.544	0.013*
		46–60	−3.857	9.372	1.000
Diastolic NIBP I versus RBP	30–45	46–60	−6.655	3.192	0.351
		61–75	−7.583	4.685	0.050*
	46–60	30–45	6.655	3.192	0.050
		61–75	−0.929	4.601	1.000
	61–75	30–45	7.583	4.685	0.050*
		46–60	0.929	4.601	0.050
Systolic NIBP II versus ABP	30–45	46–60	−3.952	4.623	1.000
		61–75	20.583*	6.785	0.616
	46–60	30–45	3.952	4.623	1.000
		61–75	24.536*	6.663	0.303
	61–75	30–45	−20.583*	6.785	0.016
		46–60	−24.536*	6.663	0.303
Diastolic NIBP II versus ABP	30–45	46–60	−2.857	2.609	0.850
		61–75	5.000	3.829	0.053
	46–60	30–45	2.857	2.609	0.139
		61–75	7.857	3.760	0.053*
	61–75	30–45	−5.000	3.829	0.139
		46–60	−7.857	3.760	0.053*

*: The mean difference is statistically significant at the 0.05 level. NIBP: Non-invasive blood pressure, RBP: Radial artery pressure, ABP: Arterial blood pressure

diverse population confirm the relationship of age and BP estimation.[14-16]

CONCLUSION

From our study, we conclude that the NIBP recording give a higher value than the corresponding invasive direct pressure recordings at the same time in the same patients. This difference becomes more pronounced with advancing age. The morphological changes of the arterial wall (arteriosclerosis) might have contributed to this discrepancy. As therapeutic interventions are based on NIBP, this fact has to be remembered before any treatment plan is done. Future studies have to be carried out to explore other influencing factors on BP recordings and necessary technological modifications in non-invasive monitors to address these issues.

REFERENCES

1. Williams B, Lacy PS, Thom SM, Cruickshank K, Stanton A, Collier D, *et al*. Differential impact of blood pressure-lowering drugs on central aortic pressure and clinical outcomes. Circulation 2006;113:1213-25.
2. Tholl U, Forstner K, Anlauf M. Measuring blood pressure: Pitfalls and recommendations. Nephrol Dial Transplant 2004;19:766-70.
3. Ochiai H, Miyazaki N, Miyata T, Mitake A, Tochikubo O, Ishii M. Assessment of the accuracy of indirect blood pressure measurements. Jpn Heart J 1997;38:393-407.
4. Ribezzo S, Spina E, Di Bartolomeo S, Sanson G. Non-invasive techniques for blood pressure measurement are not a reliable alternative to direct measurement: A randomized crossover trial in ICU. Sci World J 2014;2014:1-8.
5. Li-wei HL, Saeed M, Talmor D, Mark R, Malhotra A. Methods of blood pressure measurement in the ICU. Crit Care Med 2013;41:34.
6. Pickering TG, Hall JE, Appel LJ, Falkner BE, Graves J, Hill MN, *et al*. Recommendations for blood pressure measurement in humans and experimental animals. Circulation 2005;111:697-716.
7. Kayrak M, Ulgen MS, Yazici M, Demir K, Doğan Y, Koc F, *et al*. Comparison between brachial blood pressures obtained by aneroid sphygmomanometer and central aortic pressures: Factors affecting the measurements. Turk Kardiyol Dern 2008;36:239-46.
8. Lind L, Andersson J, Ronn M, Gustavsson T, Holdfelt P, Hulthe J, *et al*. Brachial artery intima-media thickness and

echogenicity in relation to lipids and markers of oxidative stress in elderly subjects: The prospective investigation of the vasculature in uppsala seniors (pivus) study. Lipids 2008;43:133-41.
9. Assmann G, Schulte H. The prospective cardiovascular munster (PROCAM) study: Prevalence of hyperlipidemia in persons with hypertension and/or diabetes mellitus and the relationship to coronary heart disease. Am Heart J 1988;116:1713-24.
10. Clark JA, Lieh-Lai MW, Sarnaik A, Mattoo TK. Discrepancies between direct and indirect blood pressure measurements using various recommendations for arm cuff selection. Pediatrics 2002;110:920-3.
11. Roman MJ, Devereux RB, Kizer JR, Okin PM, Lee ET, Wang W, *et al*. High central pulse pressure is independently associated with adverse cardiovascular outcome: The strong heart study. J Am Coll Cardiol 2009;54:1730-4.
12. Franklin SS, Wong ND. Hypertension and cardiovascular disease: Contributions of the framingham heart study. Glob Heart 2013;8:49-57.
13. Kannel WB. Range of serum cholesterol values in the population developing coronary artery disease. Am J Cardiol 1995;76:69C-77.
14. Shimokaze T, Akaba K, Saito E. Oscillometric and intra-arterial blood pressure in preterm and term infants: Extent of discrepancy and factors associated with inaccuracy. Am J Perinatol 2015;32:277-82.
15. Coutinho T, Turner ST, Mosley TH, Kullo IJ. Biomarkers associated with pulse pressure in African-Americans and non-hispanic whites. Am J Hypertens 2012;25:145-51.
16. Miyashita H. Clinical assessment of central blood pressure. Curr Hypertens Rev 2012;8:80-90.

How to cite this article: Sobana R, Parthasarathy S, Madanmohan T, Amirthaganesh B, Jaiganesh K. A cross-sectional analytical study on the influence of age in the precision and accuracy of non-invasive blood pressure recording compared to invasive intra-arterial pressure recording. Natl J Physiol Pharm Pharmacol 2018;8(3):436-440.

Source of Support: Nil, **Conflict of Interest:** None declared.