



Comparative Study of Invasive Blood Pressure Monitoring in Femoral and Radial Artery and their Correlation with Noninvasive Blood Pressure Monitoring

Authors

Dr Pankaj Kumar Omar¹, Dr Anikta Borkar², Dr Shipra Surin³

¹M.D. Chief Consultant Critical Care

^{2,3}Resident Officer

Corresponding author

Dr Pankaj Kumar Omar

Email: pankajomar@rediffmail.com

Introduction

In critical care units various decisions are taken on the basis of blood pressure recordings, however, non invasive blood pressure and invasive arterial blood pressure recordings often give different values, and the reason for this discrepancy is not clear. In critical care units various kind of pathological patients are seen with very different hemodynamic profiles. They may be in septic shock or circulatory failure or may be on vassopressor or vassodilators, extremities may be in vasospasm or there may be acidosis or alkalosis due to various reasons.

Oscillometric method is used in non invasive blood pressure recordings and it's widely accepted. However, invasive arterial blood pressure is considered as a standard of monitoring in patients requiring a more intense blood pressure control and monitoring.^{1,2,3,4}

Invasive and non invasive techniques often produce different values; however the relationship between these two techniques has been poorly studied.

Study by Wax et al. illustrated that there was a significant difference between the two monitoring techniques although they did not reveal the reason behind this.

Few studies have shown that cuff inflation at the arm for blood pressure measurement results in a transient rise in blood pressure^{6,7} this might be due to the ms activity or ms compression or due to the overall anxiety of knowing that blood pressure was being recorded.^{8,9,10} This phenomenon is known as the alerting response and has been studied in the non surgical outpatient population, but data regarding the same in the critical care unit is lacking.^{11,12} This information is important in critical care unit as both these techniques are often employed to guide the clinical interventions like blood transfusion, intravenous fluid, vassopressor or anti hypertensive use.

Automated non invasive blood pressure using oscillometric techniques.^{13,14} have advantages over invasive arterial blood pressure as they are non invasive and without risk of bleeding and infections and can be used out of intensive care

units. Studies have suggested that non invasive blood pressure may differ with invasive arterial blood pressure.¹⁵⁻¹⁹ Studies comparing the data from two techniques are limited in critical care units.

Aims and Objectives

To assess the significant of difference between invasive and non invasive blood pressure monitoring techniques in neurological patients in intensive care unit setup.

The objective of this study was to determine if the difference between non invasive blood pressure and invasive femoral and radial artery blood pressure was significant.

Material and Method

After approval from hospital ethics committee, the study was conducted from March 2017 to January 2018.

All neurological patients were included in the study that needs invasive blood pressure monitoring. Patient who had invasive blood pressure monitoring were also had non invasive blood pressure monitoring on the contralateral upper limb.

Patient with peripheral arterial diseases, arterio-venous fistula for maintenance dialysis, bleeding diathesis, trauma in one of the upper limbs, with accelerated hypertension and chronic renal failure were excluded from the study.

After taking written explained consent patients were enrolled for the study. Each patient was measured for both invasive and non invasive blood pressure. Simultaneously for 5 readings at five minutes interval. Readings for systolic, diastolic and mean blood pressure was recorded.

Monitors used were MP20 PHILIPS Intellivue. Single researcher gathered the data and recorded on Microsoft excel sheet.

All patients had invasive arterial blood pressure by radial/femoral arterial cannula which was inserted under strict aseptic conditions. Arterial line transducer was zeroed at heart level and beta to beat variability of blood pressure was recorded.

Appropriate sized cuff was placed on the contra lateral arm for non invasive blood pressure measurement. Base line recordings of heart rate, systolic blood pressure, diastolic blood pressure and mean blood pressure were recorded.

Data were analyzed for differences in invasive and non invasive blood pressure recordings.

Results

We studied 30 patients of age group from 18-67 years, which included only neurological and neurosurgical patients. Total of 178 non invasive blood pressure and invasive arterial blood pressure recordings were taken. We separated the study population in two groups, one with noninvasive radial arterial blood pressure vs invasive blood pressure (upper arm) and another femoral arterial blood pressure vs non invasive blood pressure (upper arm). We recorded systolic, diastolic, and mean blood pressure and Heart rate at 5 minute intervals and compared these findings with their mean \pm standard deviation and for their statistical significance.

The mean age group in non invasive blood pressure group was $38,4\pm 8.8$, femoral arterial blood pressure group 39 ± 10 and in noninvasive arterial blood pressure group was $38,4\pm 10.9$. They were comparable.

Blood pressure was measured non invasively and invasively from radial and femoral arteries separately. Recordings were taken for systolic, diastolic and mean blood pressure. Results from our study showed that systolic femoral arterial blood pressure was higher than systolic non invasive blood pressure at systolic invasive arterial blood pressure >121 mmHg and was lower than systolic non invasive blood pressure at invasive arterial blood pressure <120 mmHg. The variation in systolic non invasive blood pressure and invasive arterial blood pressure in femoral artery varied from $+22$ to -43 mmHg.

Our study showed non invasive blood pressure and invasive arterial blood pressure (123.5 ± 14.35 vs 134.03 ± 17.81), $t= 4.25$ and $p<0.001$ that

is statistically significant and recordings for systolic blood pressure from non invasive blood pressure and invasive arterial blood pressure were not comparable.

However, the mean blood pressure showed less variation in these ranges and when mean non invasive blood pressure was compared with femoral invasive blood pressure values were mean non invasive blood pressure 92.47 ± 6.94 femoral invasive arterial blood pressure 94.39 ± 9.21 , $t=1.89$ and $p>0.05$ (non significant). Mean non invasive blood pressure and femoral invasive arterial blood pressure were comparable with less variation -16 to $+12$ mmHg.

Recordings from radial artery were systolic radial invasive blood pressure blood pressure 154.3 ± 12.07 and corresponding systolic non invasive blood pressure 147.22 ± 13.96 (7.08 ± 5.36) with variation in range of $+20$ to -20 mmHg. The radial mean invasive blood pressure was 95.11 ± 8.2 while non invasive blood pressure was 87.33 ± 15.77 (7.77 ± 8.7) with variation from $+16$ to -3 and both of these values had $p<0.001$.

Discussion

This study was unique in itself as it compared invasive blood pressure from femoral and radial artery with non invasive blood pressure simultaneously, in neurological patients. We observed that systematic deviations are present in systolic non invasive blood pressure and systolic invasive arterial blood pressure. Furthermore our study showed that this variation was more pronounced between systolic non invasive blood pressure and systolic femoral arterial invasive blood pressure.

Moreover, this variation was dependant on the range of blood pressure, systolic non invasive blood pressure measures higher than femoral invasive blood pressure if invasive blood pressure is <120 mmHg and systolic non invasive blood pressure measures less than femoral invasive blood pressure if invasive blood pressure >120 mmHg. The variation ranged from $+22$ to -43 mmHg $t= 4.25$ with $p<0.001$, which was highly

significant and not comparable. So in clinical practice we found that femoral systolic invasive blood pressure was not comparable with systolic non invasive blood pressure values $p<0.001$.

At lower systolic invasive blood pressure noninvasive blood pressure measures higher and at higher invasive blood pressure non invasive blood pressure measures lower. Therefore, clinical decisions based on systolic non invasive blood pressure recordings may be misleading and injurious to the patients in deciding hemodynamic interventions.

In assessing hypotension a higher threshold should be kept for systolic non invasive blood pressure values to initiate an early protective measure.

Our findings suggest that clinical interpretation of hypotensive systolic blood pressure readings should be made cautiously in a device dependant manner.

In contrast mean arterial blood pressure are comparable when measured noninvasively in brachial artery and invasively in femoral artery. The non invasive mean arterial blood pressure was 92.47 ± 6.94 and mean invasive arterial blood pressure was 94.29 ± 9.21 , which was comparable with range of variation ranging from -16 to $+9$ $t=1.89$ $p>0.05$ which was statistically non significant.

These values agree with the previous study showing comparability of mean blood pressure by invasive and non invasive techniques.

However, we noticed this comparability in femoral artery invasive monitoring in relation to non invasive blood pressure

Our comparison with radial invasive blood pressure and corresponding non invasive blood pressure showed some different results. systolic radial arterial invasive blood pressure was 147.22 ± 13.96 as compared to non invasive blood pressure 154.30 ± 12.07 , $t=7.91$ $p<0.001$ (statistically significant) variation ranging from $+20$ to -20 as opposed to radial arterial systolic blood pressure which was higher than non invasive blood pressure, showing that radial artery

measure higher than femoral artery at the corresponding non invasive blood pressure.

Many practitioners may assume that radial artery pressure is an accurate measure of more central pressure, many investigators have found that radial pressure is often lower than femoral or aortic pressure.^{20,21}

Thus blood pressure measured by non invasive blood pressure cuff (brachial) may be a better measure of central pressure when invasive blood pressure indicates hypotension.²² Similarly it has been reported that pulse pressure amplification occurs in peripheral vessels and this may cause systolic radial blood pressure to be higher than more central pressure.²³ This may explain why non invasive blood pressure is lower than invasive blood pressure in hypertensive patients. Still some investigators have suggested that invasive blood pressure and non invasive blood pressure are interchangeable particularly for mean blood pressure.^{24,25}

The mean non invasive blood pressure was 95.11 ± 8.20 and mean radial invasive blood pressure was 87.33 ± 15.77 variation being 16 to -3 between mean non invasive blood pressure to mean radial invasive blood pressure, $t=6.89$, $p<0.001$ the difference is significant. The mean pressure is the true driving pressure for the peripheral blood flow²⁶. And taken together with measures of cardiac output permits estimation of peripheral resistance. However, ever since the advent of non invasive blood pressure assessment, clinicians have traditionally relied upon it to measure systolic and diastolic blood pressure. In contrast mean arterial blood pressure constitutes sole parameter physically measured by oscillometric techniques. Current practice guidelines have been slow to integrate non invasive mean arterial blood pressure in vital sign monitoring. The society for critical care medicine has utilized both systolic and means arterial blood pressure for defining sepsis induced hypotension .whereas mean arterial blood pressure was used in setting therapeutic goals.²⁷ our results confirm that mean blood pressure from femoral artery is the most constant metric for monitoring

blood pressure in intensive care units and is independent of measurement modality. Patients with arterial underlying pathologies might also require tracking systolic, diastolic and pulse pressure.

Our study is consistent with a prior study that demonstrated the utility of non invasive mean arterial pressure in treating hypotension in patients in critical care units.

In summary we found statistically significant difference between blood pressure measured invasively and noninvasively with non invasive blood pressure generally higher than arterial blood pressure when low and lower when invasive arterial blood pressure was high in femoral artery. While mean invasive arterial blood pressure was comparable with mean non invasive blood pressure for femoral artery.

However, in case of radial artery systolic blood pressure was higher noninvasively so also the mean blood pressure and which was statistically significant.

Therefore, we recommend mean blood pressure, either non invasive blood pressure or invasive mean blood pressure by femoral artery as a comparable guide for blood pressure measurement and hemodynamic intervention. However, further large multicentric studies are required to further strengthen our observations.

Reference

1. Sethi S. Correlation of invasive and non-invasive blood pressure: A must for management. *Indian J Anaesth.* 2010;54:581–2. [\pm C free article] [PubMed]
2. Ribezzo S, Spina E, Di Bartolomeo S, Sanson G. Noninvasive techniques for blood pressure measurement are not a reliable alternative to direct measurement: A randomized crossover trial in INTENSIVE CARE UNITS. *Scientific World Journal* 2014. 2014 353628. [\pm C free article] [PubMed]
3. Holt TR, Withington DISEASE, Mitchell E. Which pressure to believe? A

- comparison of direct arterial with indirect blood pressure measurement techniques in the peripheraldiatric intensive care unit. *Peripheraldiatri Crit Care Med.* 2011;12:e391-4. [PubMed]
4. Takci S, Yigit S, Korkmaz A, Yurdakök M. Comparison between oscillometric-llometric and invasive blood pressure measurements in critically ill premature infants. *Acta Paediatr.* 2012; 101:132-5. [PubMed]
 5. Veerman DP, van Montfrans GA, Wieling W. Effects of cuff inflation on self-recorded blood pressure. *Lancet.* 1990;335:451-3. [PubMed]
 6. Kugler J, Schmitz N, Seelbach H, Rollnik J, Krüskemperipheralr GM. Rise in systolic blood pressure during sphygmomanometry disease peripheralnds on the maximum inflation pressure of the arm cuff. *J Hyperipheralrtens.* 1994; 12:825-9.[PubMed]
 7. Veerman DP, van Montfrans GA, Karemaker JM, Wieling W. Inflating one's own cuff does not increase self-recorded blood pressure. *J Hyperipheralrtens Suppl.* 1988;6:S77-8. [PubMed]
 8. Redman S, Dutch J. Cardiovascular responses during cuff inflation in subjects who have been sensitised to the measurement of their blood pressure. *N Z Med J.* 1984;97:180-2. [PubMed]
 9. Rollnik JD, Schmitz N, Kugler J. Cardiovascular reactions induced by unpredictable, predictable, and controllable painful stimuli during sphygmomanometry. *Int J Psychophysiol.* 2001; 40:161-5. [PubMed]
 10. Czarkowski M, Zajac K, Rózanowski K. Can the pressor response acritical careompanying blood pressure measurement be limited in young, normotensive women? *Blood Press Monit.* 2008;13:1-5. [PubMed]
 11. Skov-Madsen M, Svensson M, Christensen JH. Cuff inflation during ambulatory blood pressure monitoring and heart rate. *Integroup Blood Press Control.* 2008;1:15-9. [±C free article] [PubMed]
 12. Bur A, Herkner H, Vlcek M, et al. Factors influencing the acritical careuracy of oscillometricllometric blood pressure measurement in critically ill patients. *Crit Care Med.* 2003;31:793-799. [PubMed]
 13. Geddis LA, Voelz M, Combs C, et al. Characterization of the oscillometric-llometric method for measuring indirect blood pressure. *Ann Biomed Eng.* 1982;10:271-280. [PubMed]
 14. Bur A, Hirschl MM, Herkner H, et al. Acritical careuracy of oscillometric allometric blood pressure measurement acritical careording to the relation between cuff size and upper-arm circumference in critically ill patients. *Crit Care Med.* 2000; 28:371-376. [PubMed]
 15. Araghi A, Bandiseaser JJ, Guzman JA. Arterial blood pressure monitoring in overweigh yperipheralrtensive critically ill patients: Invasive or noninvasive? *Crit Care.* 2006;10:R64. [±C free article] [PubMed]
 16. Loubser PG. Comparison of intra-arterial and automated oscillometricllometric blood pressure measurement methods in postoperipheralrative hyperipheralrtensive patients. *Med Instrum.* 1986;20:255-259. [PubMed]
 17. Pytte M, Dybwik K, Sexton J, et al. Oscillometricllometric brachial mean artery pressures are higher than intra-radial mean artery pressures in intensive care unit patients receiving norepinephrine. *Acta Anaesthesiol Scand.* 2006;50:718-721. [PubMed]
 18. Manios E, Vemmos K, Tsivgoulis G, et al. Comparison of noninvasive oscillometric-llometric and intra-arterial blood pressure

- measurements in hyperperipheral acute stroke. *Blood Press Monit.* 2007;12:149–156. [PubMed]
19. Pauca AL, Wallenhausen SL, Kon ND: Reliability of the radial arterial pressure during anesthesia. Is wrist compression a possible diagnostic test? *Chest* 1994; 105:69–75.
20. Groupavlee GP, Wong AB, Adkins TG, Case LD, Pauca AL: A comparison of radial, brachial, and aortic pressures after cardiopulmonary bypass. *J Cardiothorac Anesth* 1989; 3:20–6
21. Shin BS, Kim GS, Ko JS, Gwak MS, Yang M, Kim CS, Hahm TS, Lee SK: Comparison of femoral arterial blood pressure with radial arterial blood pressure and noninvasive upper arm blood pressure in the reperipheral fusion peripheralriod during liver transplantation. *Transplant Proc* 2007; 39:1326–8
22. Avolio AP, Van Bortel LM, Boutouyrie P, Cockcroft JR, McEniery CM, Protogerou AD, Roman MJ, Safar ME, Segers P, Smulyan H: Role of pulse pressure amplification in arterial hyperperipheral-tension: Experipheralrts' opinion and review of the data. *Hyperperipheral-tension* 2009; 54:375–83
23. 7van Egmond J, Hasenbos M, Crul JF: Invasive v. non-invasive measurement of arterial pressure. Comparison of two automatic methods and simultaneously measured direct intra-arterial pressure. *Br J Anaesth* 1985; 57:434–44
24. Mignini MA, Piacentini E, Dubin A: Peripheralripheral arterial blood pressure monitoring adiseasequately tracks central arterial blood pressure in critically ill patients: An observational study. *Crit Care* 2006; 10:R43
25. Marino P, Sutin K. *The INTENSIVE CARE UNITS Book*. Philadelphia, PA: Lippincott, Williams and Wilkins; 2007.
26. Disease-llinger RP, Levy MM, Carlet JM, et al. International Surviving Sepsis Campaign Guidelines Committee. American Association of Critical-Care Nurses. American College of Chest Physicians. American College of Emergency Physicians. Canadian Critical Care Society. Europeripheralan Society of Clinical Microbiology and Infectious Diseases. Europeripheralan Society of Intensive Care Medicine. Europeripheralan Respiratory Society. International Sepsis Forum. Japanese Association for Acute Medicine. Japanese Society of Intensive Care Medicine. Society of Critical Care Medicine; Society of Hospital Medicine. Surgical Infection Society World Fediseaseration of Societies of Intensive and Critical Care Medicine: Surviving Sepsis Campaign: International guidelines for management of severe sepsis and sepatientic shock: 2008. *Crit Care Med.* 2008;36:296–327. [PubMed].