



EFFECTS OF SPINAL ANESTHESIA ON NON-INVASIVELY MEASURED CENTRAL AND PERIPHERAL BLOOD PRESSURE: A PROSPECTIVE OBSERVATIONAL-BASED CROSS-OVER STUDY.

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ABSTRACT

Vital organ perfusion largely depends on central blood pressure; thus, its maintenance and measurement seem to be important during spinal anesthesia to avoid morbidity and mortality and to achieve an optimal outcome. Spinal anesthesia brings major hemodynamic changes in the body with the potential of organ hypoperfusion mainly through its sympatholytic effects. Physicians largely depend on peripheral measurements of hemodynamics for day-to-day evaluation and medication. This may be because of the difficulty in measuring central blood pressure that often involves single or multiple invasive techniques at a time. Through newer developments in the armamentarium of hemodynamic evaluation techniques, it is now possible to measure central blood pressure using a non-invasive manner adopting oscillometric methods and larger-sized cuff. Values obtained with this technique have been validated by different studies in the various clinical scenario. So far, no study has been performed to find out the changes in central blood pressure via non-invasive methods following spinal block. In this cross-over study, we have worked to measure the degree of changes in Central and Peripheral Blood pressure after the introduction of spinal anesthesia among non-obstetric adult patients scheduled for routine surgical procedures with an aim of more appropriate maintenance of the vital functions.

KEYWORDS

Central Blood Pressure, Peripheral Blood Pressure, Spinal Anesthesia, Non-obstetric surgery.

INTRODUCTION

Central blood pressure (CBP) is the pressure in the Aorta that is reflected into the great vessels exiting from the heart such as Subclavian Artery due to its elastic nature. The term CBP usually refers to the pressure in the aorta near the heart (McGrath et al., 2001).

The pressure in the blood vessels supplying the brain and heart (through coronary sinus) is also determined by CBP — any major decrement or fluctuation may render altered coronary/cerebral circulation resulting to situations similar to altered perfusions to these organs (O'Rourke et al., 1968). Goals of anesthesia is targeted maintenance of cerebral, cardiac and renal circulation at their best. It may thus, implicate, that changes in peripheral pressure may not reflect actual circulation or perfusion to these organs (Asmar et al., 2001). Whereas, changes in central blood pressure are likely to simulate changes in the circulation milieu in these organs, thus, highlighting the importance of measurement and maintenance of central blood pressure (Murgo et al., 1980).

Spinal anesthesia (SA) brings major fluctuations in hemodynamics - be it in Stroke Volume (SV), Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Systolic Vascular Resistance (SVR), Mean Arterial Pressure (MAP), Cardiac Output (CO) etc; thus, indicating compromised perfusion in major vital organs when adequate pressure head is not maintained by various interventions. Hence, maintenance of stable hemodynamics that provide better perfusion to central organs even during spinal anesthesia is essential.

Though studies have well documented changes in these parameters following SA; yet, no study is available to find out the changes in central blood pressure via non-invasive methods following spinal block. However, vital organ perfusion largely depends on central blood pressure, thus, its maintenance and measurement seem to be important during spinal anesthesia to avoid morbidity and mortality and to achieve optimal outcome (Mitchell et al., 2004).

Peripheral blood pressure (PBP) is generally measured after spinal anesthesia and subsequent BP measurements are accomplished to maintain the hemodynamics. If not properly maintained, BP may be inadequate in providing perfusion in patients who have compromised end-organ circulation namely ischemic disease, diabetes mellitus, dyslipidemia, atherosclerosis, etc (Westerhof et al., 1972). It is always not practical to measure CBP through invasive devices in surgical

procedures where the large fluid shift is unlikely, however measurement and maintenance of CBP are of utmost importance because of the factors mentioned (Smulyan et al., 2008).

Various studies over the last two decades have indicated CBP as a better predictor of future cardiovascular events and is more closely related to vital organ perfusion than conventional brachial one (Nakasuji et al., 2012).

Thus, in this study we aimed to study the degree of changes of Central and Peripheral blood pressure after the introduction of spinal anesthesia among non-obstetric adult patients scheduled for routine surgical procedures.

MATERIALS AND METHODS

After approval from the Institute Ethical Committee (No- ESI-PGIMSRS/MKT/IEC/04/2017, Date- 22.12.2017), and permission from the affiliated university (West Bengal University of Health Sciences, Kolkata, India, Date- 13.09.2019) as well as informed consent from an individual patient, we had sequentially enrolled 60 patients of ASA physical status 1 or 2 in the age group of 20 to 60 years scheduled to undergo spinal anesthesia for various surgical procedures except cesarean sections. Patients were divided into 3 groups according to age groups: Gr. A (20-40 yr.), Gr. B (40-60 yr.) and Gr. C (60-80 yr.).

For measurement of Central Blood Pressure [CBP] in a non-invasive way, Pulsecor BP Plus Device, Fig 1 (Uscom Ltd, Level 8, 66 Clarence street, Sydney 2000 NSW, Australia) was used and Peripheral Blood Pressure [PBP] was measured by Riva Rocci- Cuff with the help of oscillometric methods using multipara monitors. (Space Labs Healthcare — 35301 SE Center St, Snoqualmie, WA 98065, USA). In cases of CBP measurements, the company-approved oscillometric cuff was applied on the left upper arm; while peripheral BP was measured on the right upper extremity. The Pulsecor arm cuff fits an arm circumference of 22-32 cm. Pulse Cor is tasked to determine central blood pressure by using a physics-based model of the arteries between the aorta and the cuff. These models demonstrates how pressure waves travel between the aorta and the occluded artery under the supra systolic cuff pressure (Park et al., 2010), as seen in Fig 2. With an inter-measurement interval of 2 minutes, the PBP and CBP were measured till 30-40 mins of operation. Therefore, the gap between each central to central/peripheral to peripheral was 4 minutes.

Baseline hemodynamic parameters were taken before the initiation of the spinal block.



Fig 1: This figure shows Pulsecor BP plus device that was used in our study to measure CBP.

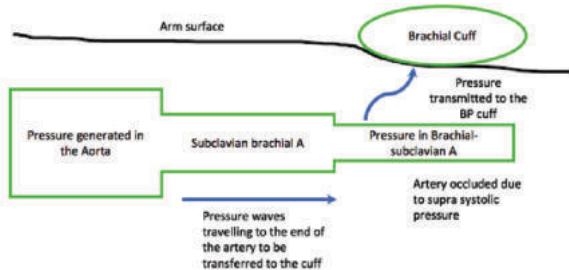


Fig 2: Model diagram showing how pressure waves travel between aorta and the occluded artery under the supra-systolic cuff.

Adopting asepsis, subarachnoid block [SAB] was performed in a sitting position through L4-L5 interspace using a 25-gauge Quincke's needle (B. Braun Medical, Melsungen, Germany). Hyperbaric bupivacaine (Anawin Heavy 0.5%, Neon Inc, Mumbai, India), 3.5 ml was injected into each patient once the free flow of cerebrospinal fluid had been ensured. The patients were positioned supine and oxygen was administered by face mask or nasal cannulae as per the requirement. Once SAB was accomplished, a stat measurement of CBP and PBP was taken followed by subsequent measurements as per the protocol stated above. All pressures were measured as Systolic and Diastolic in each method of measurement.

Study design

We have included 60 ASA-I patients undergoing non obstetrical surgery, who are divided into three groups. Group A (20-40 yrs), Group B (40-60 yrs), Group C (60-80yrs).

The study design adopted was Prospective, Observational, cohort based, Comparative, cross over study model.

RESULTS

All the three groups, A (20-40 yr.), B (40-60 yr.), and C (60-80 yr.) were found comparable with respect to age, height, fasting period (8 hours), the volume of bupivacaine injected, block height and baseline Peripheral and Central BP [Table-1].

Table 1: Demographic Parameters and Baseline Hemodynamic data of patient population

Demographic profile	Group A	Group B	Group C
N	20	20	20
Age (Years)	29.90 ± 5.85	48.5±5.58	67.75±4.75
Weight (Kg)	58.2±6.78	62.85±8.12	66.7±/-8.86
Height (cm)	154.9±8.01	158.5±8.88	160.25±9.04
Mean CBP (mm Hg)	SBP 119.62± 18.48	119.78 ± 17.15	144.5 ± 19.15
	DBP 80.0± 14.05	82.22±13.31	85.4± 9.5
Mean PBP (mm Hg)	SBP 130.87± 13.33	129.89 ± 18.39	151.8± 17.7
	DBP 83.625± 9.8	83.77± 10.66	83.2± 8.6
Block height (Thoracic Dermatome T2-T8)	6(3-8)	6(3-8)	6(2-8)
Vol of Bupivacaine injected (ml)	3.2(2.8-3.4)	3.2 (2.8-3.2)	3.0(2.8-3.0)

In the study population, the measured values of mean baseline Peripheral and Central systolic blood pressure (SBP) were 138.3 +/- 20.01 mm Hg and 128.9 +/- 22.02 mmHg, respectively. [p<0.005]. The similar measurements for diastolic blood pressure (DBP) were 83.51 +/- 9.91 and 82.74 +/- 12.73 mm Hg, respectively. [p<0.005] [Table-2].

Table 2: Sequential Blood Pressure Measurements (mm Hg ± SD) of Central (C) and Peripheral (P) BP Monitoring Methods with comparison of Mean values of Central SBP to Peripheral SBP and Central DBP to Peripheral DBP along with correlation (r) values.

	Baseline	P1(4 mins)	P2(8 mins)	P3(12 mins)	P4(16 mins)	P5 (20 mins)	P6 (24 mins)	P (7/28 mins)
P (Mean ± SD)	SBP	138 ±20.01	126.88 ±19.04	116 ±21.32	113.1 ±17.19	114 ±15.40	116 ±17.06	113 ±17.81
	DBP	83.51 ±9.91	77.33 ±12.28	72.74 ±11.23	71.62 ±11.70	70.62 ±11.23	71.33 ±11.29	68.85 ±9.10
C (Mean ±SD)	SBP	128.88 ±22.02	114 ±17.52	104 ±21.40	100 ±17.17	104 ±18.54	107 ±19.96	103 ±16.73
	DBP	82.74 ±12.73	75.33 ±13.03	67.85 ±11.44	66.88 ±11.44	66.66 ±12.09	67.59 ±11.2	67.74 ±11.09
Correlation (r)	SBP	0.996	0.995	0.989	0.992	0.995	0.988	0.993
	DBP	0.994	0.993	0.979	0.984	0.982	0.978	0.983

In all groups combined, it can be seen from Fig.3 that there was a fall in both Central and Peripheral SBP as well as DBP after the institution of SA, moreover, the fall in the systolic BP is more in Group C, i.e. older age group compared to younger age groups - Group B and Group A [p<0.005]. The fall of BP, both in terms of Peripheral and Central BP, is more in the third reading [P3], i.e., 8 mins after the insertion of subarachnoid Bupivacaine. It is evident from Table-2 that following sequential measurements over time after induction of SA, both the Central and Peripheral SBP and DBP values had fallen from their respective baseline values [p<0.005]. Over subsequent measurements, the fall of Systolic PBP and CBP were both seen to be maximum at P3(8 min after SA), the systolic PBP fell by about 25 mmHg from baseline value [p<0.0003] (approx. 18%), and the systolic CBP fell by about 28 mmHg [p<0.0003] (fall by 22%).

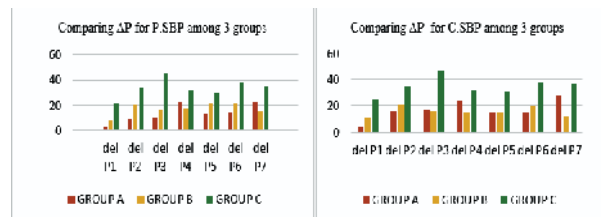


Fig 3: Comparison of ΔP, ie, fall of SBP among the three groups after administration of Bupivacaine. The fall in both P-SBP (left fig) and C-SBP (right fig) was seen to be more among the older age group (Group C) as compared to younger age group, Group A and Group B. As evident from Fig 4, the fall of SBP and DBP is more in Central than Peripheral BP [p<0.005] among the elderly population. Table 3 depicts that the ΔP, i.e., the mean value of the difference in BP from baseline values was found to be 13.41 ± 7.91 mmHg [p<0.005] for Peripheral SBP; whereas, for Central SBP it was 15.12 ± 8.72 mmHg [p<0.005]. In a similar manner, the difference in values for Peripheral and Central DBP was 8.49 +/- 2.59 mmHg and 9.46 +/- 3.15 mmHg, respectively [p<0.039].

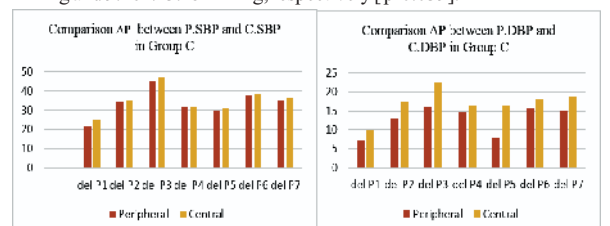


Fig 4: Comparison of ΔP between Peripheral and Central BP in Group C

C. The fall in systolic (left fig) and diastolic (right fig) BP was seen to be more in central BP than in peripheral BP in elderly population namely Group C.

Table 3: Mean Δ -P of Systolic and Diastolic Blood Pressure by central and peripheral methods done by paired t-test.

Groups	N	Mean	Std Deviation	Std Error Mean	P-value
Peripheral SBP	7	-13.417	7.992	3.02	0.005
Central SBP	7	-15.126	8.722	3.29	
Peripheral DBP	7	-8.496	2.590	0.979	0.039
Central DBP	7	-9.460	3.1589	1.196	

DISCUSSION:

In our study, we found out that the baseline central SBP was significantly lower than the baseline peripheral SBP; whereas, the central DBP was almost closer to peripheral DBP; however, the former was still lower than the latter. This is probably because of the augmentation phenomenon (O'Rourke et al., 1968) and also due to variability of arterial stiffness in different arteries (Asmar et al., 2001). In our study, the fall in both the systolic and diastolic blood pressure measured by peripheral and central methods of measurement was maximum in the 4th and 8th min after administration of subarachnoid block. The blood pressure gradually became closer to the baseline in subsequent measurements. Hypotension usually occurs within the first 30 mins of SA, usually maximally between 10-12 mins (de Luca et al., 2004). Compared to other groups, patients in group C (60-80 yrs.), had more falls in SBP than other subgroups following administration of SA and the fall in Central blood pressure was more than that of Peripheral blood pressure. This is probably due to the fact that elderly people usually have higher vascular stiffness, vascular degeneration, and sclerosis with enhanced vascular basal tone compared to younger people (Party et al., 1992). Therefore, following spinal-induced sympatholysis, the rate of vascular relaxation is more predominant among the elderly than the younger ones resulting in a greater fall in systolic pressure. However, systolic pressure is actually the forwarding force required for the flow of blood to pass through vasculatures. Therefore, as the vascular system stiffens with age, so also the systolic blood pressure tends to move in an upward direction as compared to a younger age to maintain the perfusion of organs against many odds (Choi et al., 2010).

In the perioperative setup, anesthesiologists across the globe rely mostly on peripheral BP measurements – be it measured either invasively or non-invasively to maintain the perfusion of central organs. However, as cardiac perfusion depends largely on the central pressure head (Roman et al., 2010), measurement of peripheral pressure may not reflect the actual values of central pressure (especially in a situation of the sympatholytic situation arising from the spinal block) to take appropriate volume/pressure-based modalities for maintenance of cardiac perfusion. This is much more important for patients with ischemic heart disease who often tend to develop ST segment alterations with changes in blood pressure (Boutouyrie et al., 2000) – more so during surgical procedures that entail many more other stress factors such as rapid volume loss in a short span of time. Thus, targeting blood pressure measurement according to changes in central blood pressure has a strong physiological basis to avoid unnecessary development of pathological situations – such as an increase in the rate of perioperative vital organs morbidity and mortality – such as ischemia of the heart, or poor perfusion of the kidney. No studies have been conducted to find out the impact of SA on CBP during the peri-op period. Since there is a scope for documenting the impact of SA on CBP vis-a-vis PBP, we conducted this study to compare the changes in the parameters of these two pressure measurements using the non-invasively measured technique of CBP.

Compared to the older group, degeneration and sclerosis-related changes in the vasculature are least in the younger group, thereby, their vasculatures have lesser stiffness (Hashimoto et al., 2007). A major factor affecting systolic blood pressure in this group is basal vascular tone and expansibility during the cardiac cycle (Jatoi et al., 2007). Accordingly, a sympatholytic situation such as SA affects less on their stiffness component among young individuals. This effect prevents sharper falls or larger falls in blood pressure when compared to the older generation.

Because of these facts, it was seen in our study that the Δ P fall of CBP is always more than that of the PBP, more so in the elderly patients. This

reflects the need of monitoring CBP more than PBP during SA as CBP co-relates more to direct cardiovascular dynamics compared to PBP (Asmar et al., 2001; Boutouyrie et al., 2000). It has been observed that BP waves differ notably between central and peripheral sites due to amplification. This phenomenon is more evident in the older age group. Hence the fall in PBP might not adequately represent the changes in hemodynamics occurring after SA.

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3. Conflict of interest:

All the authors hereby declare that we do not have any conflict of interest to declare.

4. Author Contribution Statement

Dr Saptaparni Hazra performed clinical experiments on the patients, collected the data, performed interpretation and statistical analysis of data and drafted the manuscript. Dr Monimala Sen conceptualized the study hypothesis and study design. Dr Gourab Paul has helped in the compilation of data for statistical analysis. Dr Binay Kumar Biswas supervised the clinical experiment, edited and revised the manuscript for final submission. The manuscript has been read and approved for submission by all the named authors.

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