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Original Research Article

Comparison of haemodynamic parameters in two different geriatric age groups undergoing cemented bipolar hemiarthroplasty

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ABSTRACT

Background: To conduct a prospective observational study to compare the haemodynamic changes in two age groups, group A: 60-75yrs and group B: >75yrs during cemented bipolar hemiarthroplasty for hip fractures under spinal anaesthesia.
Methods: Patients of either sex belonging to above two groups, with no contra-indications for central neuraxial block received spinal anesthesia at lumbar level. Heart Rate (HR), Systolic Blood Pressure(SBP), Diastolic Blood Pressure(DBP) and Mean Arterial Pressure(MAP), pulse pressure variability(PPV), arterial oxygen saturation (SpO2), Electrocardiogram for any changes and nasal end tidal CO2 (EtCO2) were recorded at the following time points: baseline(on table), after giving spinal, after giving surgical position, at the start of surgery, at femoral canal reaming, immediately after cement insertion, every 2 minutes after cement insertion, femoral joint reduction and the end of the surgery. Hypotension, bradycardia, arrythmias, desaturation or unexpected loss of consciousness occurring in peri-cementation period suggestive of 'Bone cement implantation syndrome'(BCIS) or any other adverse event was recognized and treated.
Results: The SBP, HR, PPV, ETCO2, SPO2 and incidence of adverse events; were comparable in both the groups. The difference in the DBP and MAP was statistically significant.
Conclusions: The difference in the occurrence of haemodynamic alterations was more in the older age group. Continuous vigilant monitoring during bipolar hemiarthroplasty is required.

Keywords: Bone cement, Geriatric, Haemodynamic, Hemiarthroplasty

INTRODUCTION

The population of India has increased by 38% over the past two decades and the percentage of population above age of 60 has almost doubled.[1] In the recent years there has been a steady rise in the geriatric population coming for various surgical procedures probably due to improvement in health care facilities.[2] Bipolar hemiarthroplasty (cemented or un-cemented) is one such procedure. It is frequently performed for fracture neck / inter-trochantric femur in geriatric age group. Cemented bipolar hemiarthroplasty is preferred in old age with osteoporotic and thin cortical bones.[3] Cement used is usually polymethylmethacrylate.[2-4] Procedure of cementing involves an exothermic reaction causing intramedullary hypertension. This can cause myriad of complications like fat, bone marrow, cement or air embolism leading to haemodynamic and cardiorespiratory alterations.[3] These complications are said to vary with age, co-morbid illness and compromised functional status.[4-6] This leads to increased risk of perioperative morbidity and mortality.[7-8] There were

studies comparing haemodynamics during the above procedure in two age groups but none in the Indian population. Hence we decided to conduct a study in our tertiary care institute.

METHODS

After institutional ethics committee approval, and CTRI registration (Registration no:CTRI/2017/04/008301) a prospective observational study was carried out in patients of either sex belonging to two age groups, Group A (60-75yrs) with 40 patients and Group B (>75yrs) with 26 patients who were posted for bipolar hemiarthroplasty in our tertiary care institute. This study was conducted between April 2017 and October 2017.

Sample size of 66 has been calculated based on available reference studies, within 95% confidence limit and 90 % of power.

Inclusion criteria

Consenting patients aged 60 years and above, posted for Bipolar Cemented Hemiarthroplasty and without absolute contra-indications for central neuraxial block.

Exclusion criteria

Those patients with decompensated systemic disease, coagulopathy, raised intracranial pressure, indeterminate neurological disease, infection at the site of injection and those refusing central neuraxial anaesthesia.

Patients scheduled for cemented bipolar hemiarthroplasty were thoroughly evaluated and assessed preoperatively and those fulfilling the inclusion criteria were enrolled in the study. A Hb of <10g/dl if present was corrected with preoperative transfusion.

Patients enrolled were divided into two groups as per their age, group A (60-75yrs) with n=40 and group B (>75 yrs) n=26.

On the operation table, standard monitors which include cardioscope, non-invasive blood pressure monitor, a pulse oximeter, ETCO2 using the nasal ETCO2 sampling cannula were attached and baseline (on table) readings were recorded. A 20 gauge arterial catheter was inserted in the radial artery for invasive blood pressure monitoring. Non-sedative premedication in the form of intravenous pantoprazole 40 mg and ondansetron 4mg was uniform for all the patients.

All patients received subarachnoid block (SAB) with 10-12 mg of 0.5% hyperbaric bupivacaine with 10µg of fentanyl following a standard technique through lumbar (L3-4 or L2-3) intervertebral spaces. Epidural catheter was inserted prophylactically in all patients to supplement anesthesia only if required and to provide postoperative analgesia. Patients who required epidural anaesthesia during surgery were excluded from the study.

Patients were made supine after giving spinal anesthesia and a maximum sensory level of T10 was achieved. Crystalloid infusion (5ml/kg) was administered during spinal anesthesia to prevent hypotension. Patients were maintained in the supine position for 15 minutes before giving lateral position for surgery. All patients received Oxygen via nasal cannula @ 2 L/min. HR, Invasive Blood Pressure (systolic, diastolic and mean arterial pressure), PPV, SpO_2, Electrocardiogram for any changes and nasal $EtCO_2$ were recorded at the following time points: baseline(before induction), after giving spinal anesthesia, after giving surgical position, at the start of surgery, at femoral canal reaming, immediately after cement insertion, every 2 minutes after cement insertion, femoral joint reduction, and at the end of the surgery. Duration of reaming of medullary canal, duration of cementing (defined as from the beginning of cement insertion till insertion of prosthesis) were also noted. Pre-cementing and post cementing arterial blood gases were also taken to monitor the PaO_2. Surgical measures like medullary canal preparation with cement restrictor, cementing gun, thorough lavage and suctioning and achieving good haemostasis were taken to decrease the embolic load. Medical measures like maintaining euvolemia and administration of steroid were employed. The above steps were followed for all patients.

In case of Hypotension (defined as > 20% fall in systolic blood pressure from baseline or a systolic pressure of <90 mmHg), blood pressure was supported with intravenous ephedrine in 3 mg increments to maintain the blood pressure within 20% of the baseline values. Total dose of ephedrine required was also noted. A rise in PPV of more than 10 was treated with fluid boluses of 1ml/kg. Hypotension, bradycardia, cardiac arrhythmias, desaturation or unexpected loss of consciousness occurring in peri-cementation period suggestive of 'Bone cement implantation syndrome' or any other adverse event was recorded and treated.

Statistical analysis

The Statistical software namely SPSS 18.0, and R environment ver.3.2.2 was used for the analysis of the data. Student t test has been used to find the significance of study parameters on continuous scale between two groups. Chi-square/ Fisher Exact test has been used to find the significance of study parameters on categorical scale between the two groups.

RESULTS

In this study, the proportion of females was more in both the groups. There was no statistical difference in the age distribution in the two groups (p= 0.446). (Table 1)

77.5% of the patients in group A and 84.6% of the patients in Group B had associated comorbidities (p=0.478) (Table 1). Hypertension was the most common associated systemic disease.

Table 1: Distribution of Sex, ASA grading, co-morbidities and fracture type.

Parameter		Group A (n = 40)	Group B (n=26)	p Value
Gender distribution	Male	60%	69.2%	0.446 Chi-Square test.
	Female	40%	30.8%	
ASA Grading	ASA I	5(12.5%)	4(15.4%)	P=0.430, Fisher Exact Test
	ASA II	30(75%)	16(61.5%)	
	ASAIII	5(12.5%)	6(23.1%)	
	ASAIV	0(0%)	0(0%)	
Comorbidities		Group A	Group B	
Hypertension		18(45%)	15(57.7%)	P=0.478, Chi-Square Test
Diabetes Mellitus		5(12.5%)	5(19.2%)	
Ischaemic Heart Disease		2(5%)	1(3.8%)	
Bronchial Asthma		2(5%)	0(0%)	
Epilepsy		1(2.5%)	0(0%)	
Chronic Obstructive Lung Disease		2(5%)	0(0%)	
Psyciatric illness		1(2.5%)	0(0%)	
Stroke		0(0%)	1(3.8%)	
Fracture Type	TC Neck(84%)	34(85%)	22(84.6%)	P=1.000, Fisher Exact Test
	IT-Femur (15.2%)	6(15%)	4(15.4%)	
Parameter		Mean±SD	Mean±SD	p value
Duration of reaming(min)		13.00±4.30	11.85±4.76	0.311
Duration of cementing(min)		16.48±3.83	17.23±3.49	0.421
No of patients requiring ephedrine		11.14±3.98	10.20±2.89	P=0.531
Percentage of patients having a sensory level - T10		65%	61%	P=0.8

More number of patients in group B (23%), than in group A (12.5%) belonged to ASA III but the difference was not statistically significant (Table 1).

Table 2: Adverse events.

Adverse Events	Group A	Group B	p value
Hypotension	8(61.5%)	7(70%)	1.000
Desaturation	4(30.8%)	0(0%)	0.104
Bradycardia	1(7.7%)	0(0%)	1.000
Hypoglycaemia	0(0%)	1(10%)	0.435
Metabolic acidosis	0(0%)	1(10%)	0.435
Acute renal failure	0(0%)	1(10%)	0.435
Total no of adverse events	13(100%)	10(100%)	-

The distribution of patients based on the type of fracture femur, trans-cervical (TC) neck or inter-trochantric (IT) fracture is as shown in Table 1 (P=1.000).

The mean HR, SBP, $ETCO_2$, SpO_2 and PPV were comparable at all times between the two groups. (Figure 1 and 2). There was fall in both DBP and MAP in both the groups after giving subarachnoid block (Figure 1). The mean DBP and MAP was lower at all points in group B than in group A, the difference being maximum during reaming and during cementing (P< 0.001).

The total number of adverse events was 13 in group A and 10 in group B (P=0.792). Hypotension was the commonest of all the adverse events (Table 2).

There was no significant difference in the pre and post cementing PaO_2 values between the two groups. (P >0.05) (Table 3).

Table 3: Comparison of PaO_2.

PaO_2	Group A	Group B	p value
Pre cementing	139.98±52.42	147.61±72.22	0.621
Post cementing	127.63±52.82	130.97±55.56	0.807
p value	0.021*	0.080+	-

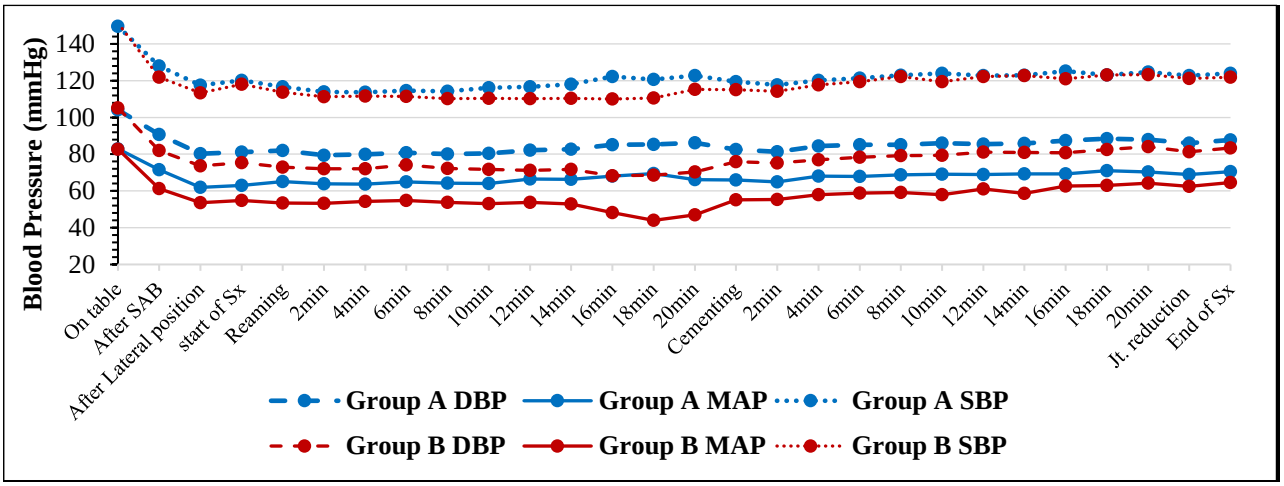


Figure 1: SBP, DBP and MAP tracing at different times among two groups.

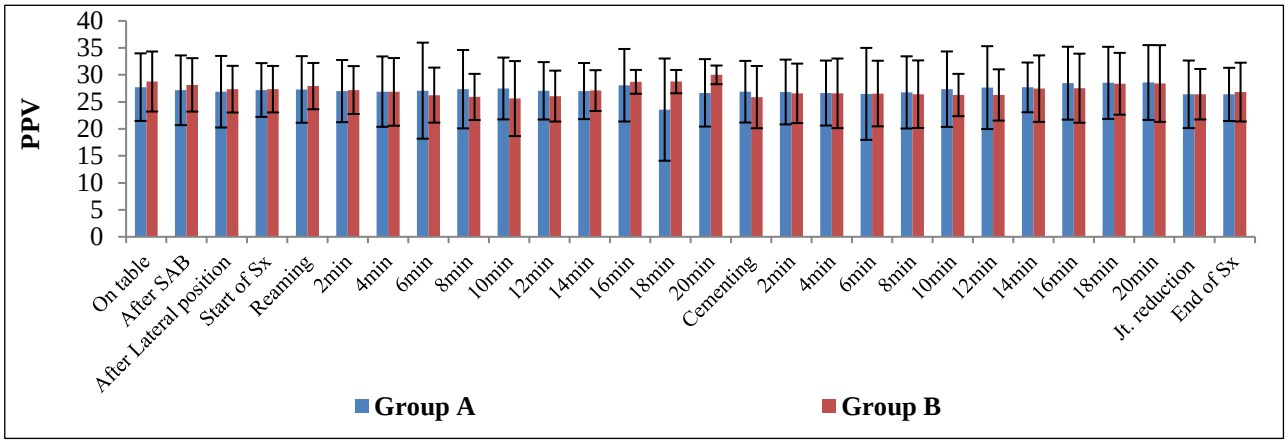


Figure 2: PPV values at different times among two groups.

DISCUSSION

Cemented Bipolar hemiarthroplasty is preferred (over un-cemented) in elderly patients as the cement reinforces the osteoporotic proximal femur thus promoting increased level of activity and decreasing the pain.[9]

The process of cementing (insertion of cement in the medulla) causes exothermic reaction (>96˚C) leading to rise in the intramedullary pressure which causes the medullary contents to escape into interstices of bone and embolise. These emboli may reach the pulmonary circulation leading to hypoxia and right ventricular failure.[10]

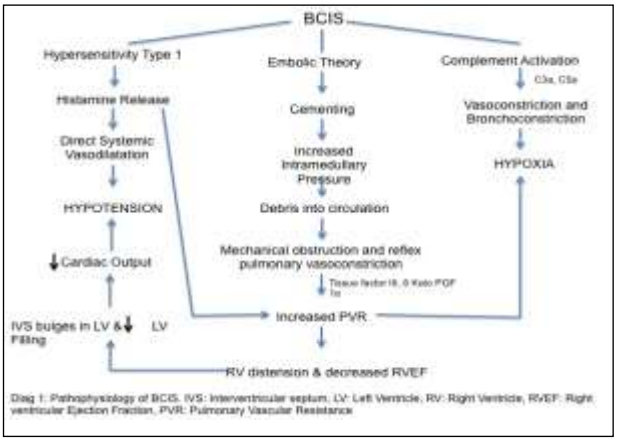
Thus the above phenomenon known as "Bone cement implantation syndrome" may be summarized by hypoxia, hypotension or both or unexpected loss of consciousness occurring at one of the following time points during surgery that is reaming, cementing, inserting prosthesis, reduction of joint and occasionally tourniquet deflation. During reaming, cementing and insertion of prosthesis there is embolism due to raised intramedullary pressure.[4,11,12] Whereas during joint reduction, the previously occluded vessels open and collected debris may enter the circulation.[4,13] The phenomenon of BCIS has two theories Embolic and Hypersensitivity theory (Figure 3).[4, 14,15]

Another concern is the geriatric physiology, their decreased functional reserve and associated comorbid illnesses.[4]

In this study the Demographic data and Categorical data (Table 1) was comparable in the two groups similar to Park et al.[2]

Mean Heart rate was comparable in the two groups at all times except at joint reduction and the end of surgery. This was similar to the observations reported by Park et al.[2] One patient in Group A had bradycardia but responded to a single dose of atropine of 0.6 mg IV. The bradycardia could be a manifestation of a varying spectrum of BCIS as it occurred specifically during

reaming. Soleimanha et al, in their study reported a rise in heart rate immediately after cementing but none of the patients had bradycardia.[16]



IVS: Interventricular Septum, LV – Left Ventricle; RV – Right Ventricle, RVEF – Right ventricular ejection fraction; PVR – Pulmonary Vascular resistance.

Figure 3: Pathophysiology of bone cement implantation syndrome (BCIS).

Though the SBP in the two groups was comparable, the DBP and MAP were significantly lower in group B. This could be attributed to the decreased cardiopulmonary reserve in the older age group due to decreased capacity to defend their cardiac output against perioperative challenges. Age related decreased contractility, diastolic dysfunction and decreased beta–adrenergic sensitivity may also play a role.[17-19] Park et al found no difference in MAP in the old and the very old age group.[2] However they measured the stroke volume and cardiac index which was much lower in very old group.

The intra-group HR, SBP, DBP, MAP in each of the two groups, showed moderate to strongly significant fall at various time points that is after SAB, after reaming, after cementing and after joint reduction compared to baseline readings. Modig et al, Soleimanha et al, also found marked decrease in arterial blood pressure after impaction of prosthesis and cementing respectively.[11,16] Urban et al found a minimal decrease in RVEF (Right ventricular ejection fraction) whereas Le Font et al found no changes in haemodynamics. But both of them found emboli traversing the RA(Right atrium) and RV(Right ventricle)on Transesophageal Echocardiography (TEE).[10,20] Kotyra et al, reported a decrease (10%) in MAP, cardiac index and stroke volume index, while Pulmonary artery pressure and the pulmonary vascular resistance index (45%) increased after cementing and prosthesis insertion.[14] Xiangbi et al, found significant decrease in blood pressure(SBP and DBP) 1min after cement implantation in the group where the medullary cavity was not flushed with epinephrine.[21] Above differences in various studies may be explained by differences in the surgical techniques and the cardiopulmonary reserve of the patients.

The End Tidal CO_2 in the two groups was comparable at all time points.

SpO_2 was comparable at most times except at baseline, after SAB, after lateral position and the start of surgery. These changes were although clinically not significant, the statistical significance (P=0.44) was because at lower standard deviations small differences become significant.

The PaO_2 (pre and post cementing) were comparable in the two groups. Group A showed a significant decrease in the PaO_2 values post cementing, when compared with the pre-cementing values (Table 3). This could be because more patients in group A than in group B had pre-existing pulmonary disease described in Table 1. Modig et al, had similar findings.[11] Lafont et al, found no changes in PaO_2 in patients undergoing cementing inspite of finding emboli traversing the RA and RV on TEE.[20] Inspite of fall in PaO_2 post-cementing most patients did not desaturate (except four in group A). This is because the small emboli lodge in the terminal pulmonary vessels. The larger vessels that supply the functional gas exchange units are usually spared, maintaining a normal ventilation and perfusion relationship.[4,22]

The most common adverse event was hypotension defined as decrease in SBP <90mmHg occurred during reaming and cementing in both age groups which was comparable in the two age groups (Table 3). It was never severe and responded well to intravenous fluids and ephedrine. The severity of hypotension was clinically more in group B than in group A and so was the requirement of ephedrine. The mean ephedrine required was more in group B (5.3mg) than in group A (3.9mg). But there was no difference in the number of patients requiring ephedrine.

Four of the patients in group A desaturated (SpO_2 <95%) during cementing. This was transient and was treated with supportive measures. Xiangbi et al, found significant decrease in saturation after cement implantation in the group where the medullary cavity was not flushed with epinephrine.[21] Le Font et al, on the contrary had no desaturation inspite of observing echogenic material traversing the RA and RV on TEE.[20] Two of the patients who desaturated had COPD(Chronic obstructive airway disease)and the other 2 had Bronchial Asthma(BA). Type I Hypersensitivity is common in patients with BA. Administration of corticosteroids may be beneficial in this case. In COPD patients Right ventricular dysfunction and pulmonary hypertension exists secondary to vascular remodelling.[23] So in these patients there is increased tendency to desaturate with sudden rise in PVR. Besides hypotension and desaturation, the other adverse event in group A was bradycardia in one patient. All of the above can be explained by pathophysiology of BCIS (Figure 1).

Acute renal failure, hypoglycaemia and metabolic acidosis which occurred in Group B patients were related

to their comorbid conditions and not due to the procedure of bipolar hemiarthroplasty.

The incidence of BCIS (as per definition) was 30% in group A and 27% in group B but the difference was not significant(P=1.00). The occurrence of BCIS was limited to grade I[Moderate hypoxia(spo2<94%) or hypotension(fall in SBP>20%)].[4]

However, Olsen et al had an incidence of BCIS grades I, II[Severe hypoxia(spo2<88%) or hypotension (fall in SBP>40%) or unexpected loss of consciousness] and III[requiring Cardiopulmonary Resuscitation] as 21%, 5.1% and 1.7%, respectively.[23]

PPV is a dynamic parameter used to monitor fluid responsiveness in mechanically ventilated patients. However, PPV may not be a reliable haemodynamic variable in spontaneously breathing patients.[24-27] In this study, we simply monitored PPV during various surgical time points and observed the trends of PPV over time and the changes were compared in the two groups. Authors did not find any significant difference in the mean PPV values between the two groups. The intragroup change in PPV when measured at various time points. The difference was insignificant.

The intragroup change in PPV was measured at various time points. Author thus found the haemodynamic changes during the peri-cementing period to be more in the older age group especially especially DBP and MAP which was much lower in the older age group.[18,19] The SBP, HR, SPO_2, PPV, adverse events, incidence of BCIS were statistically comparable among the two age groups.

Treatment of BCIS when suspected clinically is mainly supportive with administration of intravenous fluid, steroid and 100% oxygen. Le Font et al, concluded that most patients tolerated the phenomenon of BCIS well.[20] Similarly Byick et al, concluded that "cement implantation syndrome is a time-limited phenomenon".[8] The underlying problem, acute pulmonary hypertension and secondary RV failure, is reversible and not related to the embolic load but to the degree of RV dilatation. When it happens, the vigilant anaesthetist can contribute to patient safety by treating acute RV failure and maintaining coronary perfusion pressure.[28,29]

CONCLUSION

Author conclude that the haemodynamic changes during the peri-cementing period to be more in the older age group. The incidence of BCIS was comparable in both the age groups. The DBP,MAP were lower in the older age group. All other haemodynamic parameters were comparable in both age groups. Desaturation was more in patients with decreased cardiorespiratory reserve. Continuous vigilant monitoring during bipolar hemiarthroplasty is required. With early diagnosis of BCIS and initiation of supportive measures even the very old (>75 yrs) population can survive this phenomenon.

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