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Original article

Hemodynamic Effects of Continuous versus Single Dose Spinal Anesthesia in Octogenarians Undergoing Hip Surgery: Randomized Control Trial

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ABSTRACT

***Background*:** Continuous Spinal Anesthesia (CSA) is an underused regional anesthesia technique. But with the increased Geriatric population presenting to surgeries, CSA with its relative hemodynamic stability is coming back to anesthetists' interests. Better control of hemodynamics is advantageous in elderly patients and those with cardiac diseases. ***Objective*:** To compare the incidence of hypotension in continuous spinal anesthesia CSA versus single dose spinal anesthesia SDA in octogenarians undergoing hip surgery, the total use of Ephedrine and the incidence of spinal complications. ***Methods*:** Forty (40) patients were enrolled in the study and allocated into two groups 20 patients in continuous spinal anaesthesia group (CSA) and 20 patients in single dose anaesthesia group (SDA). ***Results*:** CSA has less effect on hemodynamics in elderly patients with fewer complications. There was a statistically significant difference in MAP between CSA group and SDA group between min 5 & min 40 with p-value <0.001. Satisfactory anesthesia was obtained using CSA, with significantly less dose of bupivacaine (SDA group (12.5±0.8 mg) vs. in CSA group (7.6±1.3 mg), p-value <0.001). And less doses of ephedrine were needed (4.5±1.7 mg in CSA group vs. 19.5±11.3 mg in SDA group, p-value 0.006). ***Conclusion*:** CSA is a safe and effective technique in minimizing the hemodynamic instability, lowering the total vasopressor need and reducing local anesthetic dose, subsequently lowering spinal anesthesia complications. CSA is better to be used in octogenarian patients with pre existing risk factors undergoing hip surgeries.

***Keywords*:** Hip Surgery; Octogenarians; Spinal; Continuous; Anesthesia

INTRODUCTION

With the increased life expectancy and increased prevalence of geriatric population among societies, and their increased liability to falls and accidents; anesthiologists are daily presented with the challenge of providing safe anesthesia and proper perioperative management for geriatric patients, while keeping in consideration their multiple comorbidities. (1)

Spinal anesthesia has been proven to be a relatively safe option for providing anesthesia for elderly patients undergoing hip surgeries. Yet a major disadvantage remains the associated hemodynamic instability namely in the form of hypotension; which is exaggerated by the lateral positioning of patients, blood loss and the poor capacity of elderly patients to compensate for hypotension. Conventional treatment of hypotension with fluid boluses and incremental doses of ephedrine could also has deleterious effects on patients with poor cardiac functions, valvular diseases namely aortic stenosis; which is extremely prevalent among geriatric population; and impaired renal functions due to long standing hypertension and diabetes Miletus (1).

Continuous spinal anesthesia CSA is an old yet underused technique of providing neuroaxial anesthesia in an incremental fashion, hence decreasing the incidence of hypotension. Since its first description in 1906, it has been riddled with myriad of potential side effects, limiting its utilization (2).

The aim of this work was to compare the incidence of hypotension (defined as decrease in blood pressure 20% from the base line) in continuous spinal anesthesia CSA versus single dose spinal anesthesia SDA in octogenarians undergoing hip surgery. Secondary outcome: to determine the total use of vasopressor (Ephedrine) in each group and the incidence of spinal complications as nausea, vomiting and post dural puncture headache.

PATIENTS AND METHODS

This is a randomized controlled clinical trial done at Ain-shams University Hospitals, Cairo, Egypt within a period of 6 months from approval of medical ethics committee. The study was conducted on 40 patients, from February to August 2022. Approval was obtained from the research ethics committee of Faculty of Medicine; Ain Shams University (FMASU MS 54/2022) and clinical trial registration (NCT05418374). A written informed consent was taken from each patient to participate in the study.

Based on a study of continuous spinal Anesthesia, assuming a rate of hypotension attacks (20% of the baseline blood pressure) of 15% in CSA group compared to 65% in SDA spinal anesthesia group, a sample of 20 patients in each group is enough to detect such difference, at 0.05 alpha error and 80% power of the test (1).

The inclusion criteria of the study were either sex, 80 years of age and older. While patients with Cardiac patients diagnosed with sever Aortic stenosis defined by echo as AVA (aortic valve area) < 1cm and MPG (mean pressure gradient) >40mmHg, cardiac patients with ejection fraction less than 40%, hemodynamic instability, Preexisting infection at the block site, allergy to local anesthetics, psychiatric illness, increased intracranial tension, coagulopathy problems and patient refusal of procedure or participation in the study were excluded from the study.

Based on this data, patients were randomly allocated into two groups with 20 patients in each group.

Preoperative settings:

All patients were assessed preoperatively by careful history taking, full physical examination, and laboratory evaluation according to institutional guidelines, ECG and ECHO.

A written consent was taken after full description of the procedure.

Intraoperative settings:

Patients were allocated in one of the 2 study groups, Group CSA received continuous spinal anesthesia and Group SDA received traditional spinal anesthesia, all standard monitors were placed (NIBP, pulse oximeter and electrocardiogram).

All patients received oxygen (3 L/min) during the procedure, including the first postoperative hours.

All patients had an intravenous line (18G cannula), 500 ml Ringer was started as a preload, airway and resuscitation equipment were readily available.

All equipment for the spinal blockade was ready for use, and all necessary medications were drawn up prior to positioning the patient for spinal anesthesia.

Patients received 0.4 mg/kg propofol IV 3 min before being turned to the lateral position for lumbar puncture.

The patient was positioned in lateral position with the injured leg up. The ideal positioning consists of having the back of the patient parallel to the edge of the bed closest to the anesthesiologist, with the patient’s knees flexed to the abdomen and neck flexed, the midline was palpated. The iliac crests were be

palpated, and a line was drawn between them to find the body of L4 or the L4–L5 interspace.

All techniques were done under complete aseptic condition using Betadine 5%.

A small wheal of local anesthetic (lidocaine 0.5%) was injected into the skin at the planned site of insertion.

In study group CSA, 18G epidural needle was inserted intrathecally at the level of L4-L5. After insertion of the Tuohy needle, the subarachnoid space was found, a 20G epidural catheter was passed 2–3 cm into the subarachnoid space. After confirmation of aspiration cerebral spinal fluid through the catheter, an initial dose 2.5 mg (0.5 ml) of plain bupivacaine 0.5% (manufactured by sunny medical) was injected. After assessment of systemic blood pressure and sensory level, the patients remained on the lateral position for 5 min and then was returned to the supine position, increments of 2.5 mg (0.5 ml) of the same solution were given every 15 minutes until reaching the required anesthetic level of T10.

In spinal group SDA, traditional spinal anesthesia was done with a 25G pencil point spinal needle at the level of L4-L5 with injection of 12.5 mg (2.5ml) of bupivacaine 0.5%. By adjusting the head level, T10 sensory block was targeted.

In both groups, patients were positioned for surgery after achieving sensory blockage of T10 level.

Continuous close monitoring of vital data and complications of spinal anesthesia were recorded till the end of surgery, Noninvasive automated arterial blood pressure, heart rate measurements and saturation were recorded before the spinal anesthesia (baseline), and vital data were monitored every 5 minutes till the end of surgery.

Hypotension was defined as a decrease in Blood pressure (20% from the baseline), and was treated with IV boluses of ephedrine 6 mg.

Bradycardia was defined as decrease in the heart rate (20% from the baseline) and was treated with atropine 1 mg.

Postoperative settings:

Monitoring vitals was done for 12 hours postoperatively for any possible complications every 10 minutes in the PACU and every 30 mins after discharge to the ward for 48 hours.

Statistical analysis

Recorded data were analyzed using the statistical package for social sciences, version 20.0 (SPSS Inc., Chicago, Illinois, USA). Quantitative data were expressed as mean± standard deviation (SD). Qualitative data were expressed as frequency and percentage.

Independent-samples t-test of significance was used when comparing between two means. Mann Whitney U test: for two-group comparisons in non-parametric data. Chi-square (x^2) test of significance was used to compare proportions between qualitative parameters. The confidence interval was set to 95% and the margin of error accepted was set to 5%.

RESULTS

Both groups were comparable regarding demographic data (age, sex and type of surgery) (table 1). There was a statistically significant difference between the time to start surgery; CSA group 21.8± 3.4 min vs. SDA group 10.4± 0.8 min, with p-value <0.001. The bupivacaine dose was significantly higher in SDA group (12.5±0.8 mg) than in CSA group (7.6±1.3 mg) with p-value <0.001 (table 2). Concerning top-up doses needed in CSA group; 1 patient (5%) needed one top up dose, 10 patients (50%) needed two top up doses, 8 patients (40%) needed three doses, and only one patient (5%) needed four top up doses.

The variation in MAP was greater in SDA group compared to CSA group (table 3). There was a statistically significant difference in MAP between CSA group and SDA group between min 5 & min 40 with p-value <0.001. The difference in p-value then became 0.01 in min 45, 0.02 in min 50, 0.04 in min 55, 0.05 in min 60, 0.04 in min 65, 0.03 in min 70 and 0.05 in min 75. Bradycardia occurred in 2 patients in CSA group (10%) vs. 3 patients in SDA group (15%). 4 patients (20%) needed ephedrine for treatment of hypotension in CSA group vs. 8 patients (40%) in SDA group, the difference wasn't statistically significant (table 4). However, the difference in ephedrine dose needed was statistically significant (p-value 0.006). The dose was 4.5±1.7 mg in CSA group vs. 19.5±11.3 mg in SDA group (table 5). As regards complications, there was no statistically significant difference between the two groups as regards postoperative nausea and vomiting (PONV), shivering and post dural punctural headache (PDPH). And there were no reported case of total spinal or spinal hematoma (table 6).

Table (1): Comparison between groups as regards demographic data.

Demographic data		CSA group (n=20)	SDA group (n=20)	T/X^2	p-value
Age (years)		83.35 ± 5.6	9.1 ± 9.1	0.6^{t}	0.53
Type of surgery	**DHS**	10 (50%)	5 (25%)	2.6 ^{x2}	0.1
	HR	10 (50%)	15 (75%)		
Sex	**male**	10 (50%)	10 (50%)	0.0 ^{x2}	1
	Female	10 (50%)	10 (50%)		

Data expressed as mean ± SD, proportion, T = student t test, X^2 = chi square, CSA= continuous spinal anaesthesia group, SDA= single dose anaesthesia group

Groups were comparable in demographic data (in terms of age, sex, type of surgery) and there was no statistically significant difference between groups (p-value > 0.05).

Table (2): Comparison between groups as regards total Bupivacaine dose.

	CSA group (n=20)	SDA group (n=20)	T	p-value
Bupivacaine dose (mg)	7.6 ± 1.3	12.5 ± 0.8	14.4^{t}	**<0.001**

Data expressed as mean ± SD, , T = student t test, CSA= continuous spinal anaesthesia group, SDA= single dose anaesthesia group

There was statistically significant difference between groups (p-value <0.001).

Table (3): Comparison between groups as regards Hemodynamic data.

MAP	CSA group (n=20)	SDA group (n=20)	T	p-value
MAP 0 mins	83.25±5.4	80.15±5.1	1.9	0.07
MAP 5 m	78.90±5.0	70.35±6.9	4.5	**<0.001**
MAP 10 m	79.60±4.8	71.85±6.0	4.5	**<0.001**
MAP 15m	81.10±4.7	72.55±6.3	4.9	**<0.001**
MAP 20m	81.50±4.3	74.60±5.3	4.5	**<0.001**
MAP 25m	81.90±4.6	75.25±4.1	4.8	**<0.001**
MAP 30m	81.70±4.9	76.20±3.8	4.0	**<0.001**
MAP 35m	81.75±4.5	76.95±4.3	3.4	**<0.001**
MAP 40m	81.70±4.3	77.30±4.4	3.2	**<0.001**
MAP 45m	81.40±3.8	77.60±4.5	2.9	**0.01**
MAP 50m	81.50±4.1	78.15±4.3	2.5	**0.02**
MAP 55m	81.60±4.6	78.60±4.4	2.1	**0.04**
MAP 60m	81.80±4.6	78.80±4.6	2.1	**0.05**
MAP 65m	81.95±4.6	78.85±4.7	2.1	**0.04**
MAP 70m	82.05±4.2	78.85±4.7	2.3	**0.03**
MAP 75m	82.20±4.2	79.20±5.1	2.0	**0.05**
MAP 80m	82.15±4.3	79.35±5.1	1.9	0.07
MAP 85m	82.30±4.5	79.55±5.0	1.8	0.08
MAP 90m	82.40±4.5	80.05±5.4	1.5	0.14

Data expressed as mean ± SD, , T = student t test, CSA= continuous spinal anaesthesia group, SDA= single dose anaesthesia group, MAP=Mean arterial blood pressure

There was statistically significant difference between groups (p-value > 0.05).

Table (4): Comparison between groups as regards the need for Ephedrine.

		CSA group (n=20)	SDA group (n=20)	X^2	p-value
Need of ephedrine	**yes**	4 (20%)	8 (40%)	1.9 ^{x2}	0.16
	No	16 (80%)	12 (60%)		

Data expressed as, proportion, X^2 = chi square, CSA= continuous spinal anaesthesia group, SDA= single dose anaesthesia group

Table (5): Comparison between groups as regards dose of Ephedrine.

	CSA group (n=4)	SDA group (n=8)	T	p-value
dose of ephedrine	4.5 ± 1.7	19.5 ± 11.3	3.7	**0.006**

Data expressed as mean ± SD,, T = student t test, CSA= continuous spinal anaesthesia group, SDA= single dose anaesthesia group

There was no statistically significant difference between the two groups but dose of ephedrine used in patient who needed ephedrine was statistically different (p-value > 0.05).

Table (6): Comparison between groups as regard complications.

		CSA group (n=20)	SDA group (n=20)	X^2	p-value
PONV	**yes**	3 (15%)	4 (20%)	0.17	0.68
	no	17 (85%)	16 (80%)		
Shivering	**yes**	2 (10%)	4 (20%)	0.78	0.38
	No	18 (90%)	16 (80%)		
PPDH	**yes**	3 (15%)	1 (5%)	1.1	0.3
	No	17 (85%)	19 (95%)		
Spinal hematoma		No cases detected			
Total spinal		No cases detected			

Data expressed as, proportion, , X^2 = chi square, CSA= continuous spinal anaesthesia group, SDA= single dose anaesthesia group, PONV= postoperative nausea and vomiting, PPDH= postpuncture dural headache

Groups were comparable in incidence of complications (as regard postoperative nausea and vomiting (PONV), shivering, post puncture dural headache (PPDH), spinal hematoma and total spinal) and there was no statistically significant difference between groups (p-value > 0.05)

DISCUSSION

Our study showed that CSA is a safe technique in octogenarian patients undergoing hip surgeries, with minimal effect on hemodynamics, decreased need for ephedrine and comparable rate of occurrence of side effects.

With increased age, a normal "aging" physiology of the cardiovascular and autonomic nervous systems occur, in the form of decreased elasticity of the vascular tree, increased sympathetic activity at rest and decreased sensitivity of adrenergic receptors, rendering geriatrics to be at an increased risk of larger decreases in systemic vascular resistance, myocardial contractility and arterial blood pressure in response to various stimuli (3).

Over the years there has been a debate over the "ideal" anesthetic technique for geriatric patients undergoing lower limb surgeries. Regional anesthesia is more advantageous as it allows patients to communicate distress, avoids the hemodynamic changes "stress response" resulting from laryngoscopy and intubation. Regional anesthesia produces vasodilation through sympathectomy, which decreases afterload and the incidence of deep venous thrombosis and pulmonary embolism. An indwelling catheter can also minimize the use of postoperative opioids by providing analgesia (4).

However, one of the most serious side effects of spinal anesthesia is hypotension, the degree of which is related to the degree of sympathectomy, which in turn is related to the dose of local anesthetic. The prospective UK ASAP-2 study concluded a significant correlation between hypotension, mortality and the dose of intrathecal local anesthetic (LA). The study suggested decreasing the dose of LA to the least possible, to reduce mortality in elderly and high risk patients. On the other hand, dose reduction could lead to inadequate level and inadequate anesthesia. (5) CSA allows gradual titration of small doses of LA till reaching the desired level, this slower onset of segmental block maintains more stable hemodynamics.

In our study, the MAP was more maintained in the CSA group compared to the SDA group (table 3). Hypotension was defined as a 20% decrease from the baseline reading to avoid severe hypotension, and was measured non-invasively. The slower and less severe decline in hemodynamics in CSA group can be explained by the slower onset of segmental block, compared to SDA group where sympathetic block occurs abruptly, allowing easier cardiovascular adaptation.

Other studies used different definitions for hypotension and others used invasive blood pressure monitoring, yet most studies found a significant decrease in blood pressure in SDA group than in CSA group. In *a 2006* study, the incidence of hypotension was significantly different between CSA and SDA groups, where 68% of SDA group experienced at least one episode of hypotension (defined as 20% decrease from systolic baseline readings), and 51% experienced at least one episode of severe hypotension (defined as a 30% reduction from systolic baseline) (1).

In a study of 100 high risk patients undergoing major orthopedic surgeries, where patients were divided into 2 groups; CSA group and continuous epidural anesthesia (CEA) group; the maximum decrease in MAP was more severe in CEA group and the difference was statistically significant. The number of patients treated for hypotension and total dose of ephedrine was more in CEA, though it was not statistically different (6). Similar results were obtained in another study, which also compared CSA with CEA (7).

There was no significant difference regarding the number patients requiring ephedrine (table 4), but the doses needed in the SDA group were significantly higher than in CSA group (table 5).

In a study similar to ours, where continuous vs single dose spinal anesthesia hemodynamic effects on elderly patients were studied, the mean dose of ephedrine was significantly higher in SDA group than in CSA group, they defined hypotension as a 25% decrease in baseline MAP (8).

In a study comparing CSA vs. unilateral spinal anesthesia (USpA), no difference in ephedrine dosage was found; however invasive blood pressure monitoring was used during this study, allowing rapid interference in case of hypotension (9). Similar results were also obtained in a Malaysian study where only two patients, out of 19 high risk patients receiving CSA, required ephedrine to treat hypotension (10).

The time to start surgery was significantly longer in CSA group compared to SDA, naturally explained by the slower progression of the block due to slower propagation of LA when injecting through a catheter.

The dose of bupivacaine was significantly lower in CSA group compared to SDA group (table 2). Similar result was obtained in a previously mentioned study (1).

In our study, the initial bupivacaine dose used in CSA was 0.5 ml of bupivacaine 0.5% (2.5 mg) and top up doses were given as needed. Of our 20 patients, 1 patient (5%) needed one top up dose, 10 patients (50%) needed two top up doses, 8 patients (40%) needed three doses, and only one patient (5%) needed four top up doses. A retrospective study of 318 cases receiving CSA, noticed that an initial dose less than 1.5 ml of bupivacaine 0.5% (7.5 mg) provided stable hemodynamics and that patients who received an initial volume higher than 1.5 ml were 2.78 times more likely to develop hypotension as compared to those who received a volume less than 1.5 ml (11).

Regarding complications, both CSA and SDA were comparably safe with low incidence of nausea, vomiting, shivering and no reported cases of spinal hematoma or total spinal (table 6). Concerning post dural punctural headache (PDPH), only 3 cases in the CSA group and 1 case in the SDA group developed PDPH.

Our relatively small sample size could have contributed to the low incidence of side effects, but several other studies reported low incidence of PDPH among elderly patients and especially in patients receiving CSA. It is reported that the incidence of PDPH decreases significantly in patients older than 60 years, with a rate of 1.5% in patients older than 70. Fibrosis of the tissue around the exits of the foramina and associated closure

of the exit pathway for a persistent CSF leak has been postulated. Also, a decreasing pain sensibility with increasing age and a decrease in distensibility of pain-sensitive structures in the cranium are also considered to contribute (12).

Concerning CSA, it's suggested that an inflammatory response is induced around the catheter site, sealing the arachnoid- dural dent and thus decreasing the CSF leak (13). A review of records form 29749 neuroaxial blocks reported a significantly reduced incidence of PDPH when an intrathecal catheter was inserted after accidental dural puncture (14).

Since its description in 1907, CSA has fallen out of grace several times. The high incidence of PDPH was one major concern; it was overcome by the introduction of micro-catheters introduced via small bore needles. But by 1992, several cases of cauda equina syndrome were reported and micro-catheters were incriminated. It was later proven that lignocaine 5% was probably the main cause behind neurotoxicity and cauda equina syndrome; still micro-catheter use was preserved to clinical trials in USA, but continued to be used in Europe (2 and 15)

The most widely used catheters for CSA now are macro-catheters (19 and 20 gauge epidural catheters) introduced through 17 or 18 gauge Tuohy epidural needles. With the high incidence of PDPH among young population; it is typically reserved for high risk patients as obstetric patients with advanced cardiac or valvular stenotic diseases, where its stable hemodynamic profile is advantageous. (16 & 17). The catheter can also provide adequate post labor analgesia and some case report suggested that injecting intrathecal saline can reduce the incidence of PDPH (13). Morbidly obese patients and those with previous spine surgeries (pregnant or not), where there is a high rate of epidural failure, are also favorable candidates and CSF aspiration is a sure sign of intrathecal placement, plus the risk of PDPH is lower in obese patients compared to non-obese ones (2).

Several limitations should be noted in our study, the small sample size could have underestimated the rate of complications, but this could be justified by the choice of age group. Secondly, we avoided using invasive blood pressure monitoring for fear of accompanying complications in such a vulnerable age group. Instead, we opted for defining hypotension as a 20% decrease in blood pressure from baseline values; most studies used a 25% or 30% reduction, to allow rapid interference.

CONCLUSION

CSA is an adequate anesthetic option for elderly patients undergoing orthopedic surgeries. Its stable hemodynamic profile is beneficial especially with the associated comorbidities accompanying old age, with a relatively low risk of complications.

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