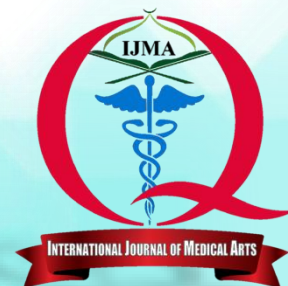


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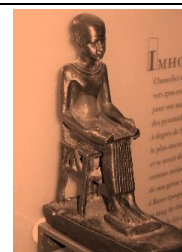
INTERNATIONAL JOURNAL OF MEDICAL ARTS

VOLUME 6, ISSUE 6, JUNE 2024

P- ISSN: 2636-4174
E- ISSN: 2682-3780



Available online at Journal Website
<https://ijma.journals.ekb.eg/>
Main Subject [Anesthesia]



Original Article

Low-Dose Sequential Combined Spinal–Epidural: An Anesthetic Technique for Lower Body Surgery in Patients with Significant Cardiac Disease

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ABSTRACT

Article information

Received: 30-03-2024

Accepted: 07-05-2024

DOI: 10.21608/IJMA.2024.280477.1952.

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Citation: Abdelazeem EM, Mostafa IE, Elmeliegy MF. Low-Dose Sequential Combined Spinal–Epidural: An Anesthetic Technique for Lower Body Surgery in Patients with Significant Cardiac Disease. IJMA 2024 June; 6 [6]: 4486-4492. doi: 10.21608/IJMA.2024.280477.1952.

Background: Anesthetic management for patients with significant cardiac disease is challenging and may be associated with high morbidity and mortality. Low-dose sequential combined spinal–epidural anesthesia [CSEA] is advantageous over single-shot spinal and epidural anesthesia as it provides rapid onset, efficacy, and minimal toxicity.

Aim of the work: This study is planned to assess the safety of small-dose sequential CSEA in high-risk cardiac patients undergoing lower body surgeries and to estimate changes in hemodynamics, vasopressor use, surgeon satisfaction, and patient satisfaction.

Patients and Methods: Sixty adult cardiac patients [5 with pulmonary hypertension, systolic pulmonary artery pressure > 50 mmHg] and fifty-five with low systolic function [ejection fraction < 40%] planned for a lower body procedure were included in our study. The CSEA technique was done with patients receiving spinal anesthesia with 5 mg 0.5% hyperbaric bupivacaine plus 20 µg fentanyl, followed by an epidural top-up of 5 ml 0.25% isobaric bupivacaine. Hemodynamic parameters and block characteristics were recorded.

Results: There were no differences in the demographic data of the patients. No significant hemodynamic changes occurred during the procedure; hypotension happened in 5% of patients and bradycardia in less than 2% of patients. There were no arrhythmias or post-operative ECG changes, and postoperative troponin was negative. There was no postoperative nausea or vomiting.

Conclusion: We conclude that low-dose sequential CSEA is a secure and efficacious method for patients with significant cardiac disease scheduled for lower body procedures.

Keywords: Anesthesia; Combined spinal epidural; Cardiac disease.



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INTRODUCTION

The number of patients with significant cardiac diseases is rising these days due to advancements in diagnosis technology and an increase in aging population numbers. In order to provide better care and improve outcomes for these patients, if they present for anesthesia and surgery, Anaesthesiologists must be aware of the pathophysiology of these disease types ^[1].

Patients with pulmonary hypertension need specific anaesthetic considerations when undergoing surgery and anesthesia due to the fact that it increases their morbidity and mortality. Stress, pain, and ventilation can raise pressure and resistance inside the pulmonary circulation and lead to right sided heart failure. Regional anaesthetic methods display the advantages of maintaining cardiovascular stability, not impairing spontaneous breathing, early postoperative mobilization, and postoperative analgesic management ^[2].

Cardiomyopathies are a heterogeneous group of pathologies characterized by structural and functional alterations of the heart. The recently proposed MOGE[S] nosology system embodies all of these characteristics and describes the morpho-functional phenotype [M], organ[s] involvement [O], genetic inheritance pattern [G], etiological annotation [E], including genetic defect or underlying disease/substrate, and the functional status [S] of the disease using both the American College of Cardiology/American Heart Association stage and New York Heart Association functional class. The proposed nomenclature is supported by a web-assisted application and assists in the description of cardiomyopathy in symptomatic or asymptomatic patients and family members in the context of genetic testing ^[3].

The best anaesthetic management of patients with DCM requires good preoperative assessment, close perioperative monitoring, proper anaesthetic technique, optimized fluid control, and stable hemodynamics. These goals are achieved by avoiding myocardial depression, maintaining normovolemia, avoiding drug overdose during induction as circulation time is slow, and avoiding sudden hypotension if regional anesthesia is of choice ^[4].

The combined spinal–epidural anaesthetic technique [CSE] has the reliability of spinal anesthesia besides the flexibility offered by the epidural catheter ^[5]. This method has recently undergone a number of changes intended to improve both safety and effectiveness. The sequential CSE

technique is a variant of the conventional CSE method. It involves inducing spinal anesthesia with a small dose of intrathecal local anaesthetic and an opioid to establish a limited block to maintain hemodynamic stability in critically – ill patients. This block can be further extended with epidural top-ups of local anaesthetics ^[6].

This study is planned to assess the safety of small dose sequential CSEA in high-risk cardiac patients undergoing lower body surgeries and estimate the changes in hemodynamic, the vasopressor use, surgeons, and patient satisfaction. The primary target is the hemodynamic variations; however, the surgeon's and patient's satisfaction are the secondary targets.

PATIENTS AND METHODS

This study was achieved on sixty adult cardiac patients, five of them with pulmonary hypertension [Systolic pulmonary artery pressure 50 mmHg] and the other fifty-five patients with low systolic function [EF \leq 40%] scheduled for lower body surgeries at Benha University Hospital from January 2023 to October 2023. The study was authorized by the Local medical ethical committee, and written informed consent was procured from all patients before surgery. All patient data was encrypted with a secret code and utilized only for this study.

Exclusion criteria were patient refusal, morbid obesity, hypersensitivity to amide local anaesthetic or opioid, patients with coagulopathy or on anti-coagulant therapy, and any other contraindication to neuraxial block.

Any unexpected risk that arose throughout the trial was promptly disclosed to the patients and the ethics committee, and appropriate management decisions were made to reduce or eliminate it.

During the preoperative visit, the procedure was explained to the patients, and a preoperative assessment was done on all patients, including history [medical, surgical, allergic, anaesthetic], examination, and investigations, including a complete blood count, coagulation profile [PT, PTT, INR], blood sampling, liver function, kidney function, electrolyte, X-ray, ECG, and echocardiogram.

All cardiac medications were continued till surgery time, and all patients premedicated with ondansetron 4 mg and famotidine 50 mg thirty minutes before anesthesia.

Once patients arrived in the operating room, standard monitoring was applied to them, including a continuous electrocardiogram, a pulse oximeter, and non-invasive blood pressure. A urinary catheter was inserted for urine output monitoring, an arterial line was inserted for monitoring of invasive blood pressure, and a central venous catheter was inserted through the right internal jugular vein for drug administration, fluid administration, and central venous pressure measurement. Baseline heart rate and blood pressure were recorded before the lumbar puncture, and recording continued at 5-minute intervals.

Anesthesia was given in a sitting position, under complete aseptic precautions after infiltrating the L2-L3 interspace with 2CC of lignocaine 2%. Epidural space was identified with the loss of resistance technique using an 18G Tuohy needle facing cranially and an epidural catheter was inserted. A test dose of 3 ml of 2% lidocaine and adrenaline 1/200000 was given through the catheter to rule out subarachnoid or intravascular placement. Spinal anesthesia was given in L3-L4 interspace using a 25 G needle and 5 mg [1cc] of 0.5% hyperbaric bupivacaine with 20 ug fentanyl injected slowly over 30 seconds. Patients were then put in a supine position after securing the epidural catheter. Then epidural was activated with 5 ml of 0.25% plain bupivacaine. Throughout the surgical procedure, anesthesia was maintained by topping up doses of plain bupivacaine [0.25% 1.5 mL] for every segment regression to maintain the surgical anesthesia level.

The duration of block performance [from local anaesthetic infiltration of skin to completion of both the 1-ml spinal and 5-ml epidural anaesthetic injections] was recorded. The patient's block profile was estimated at 5-minute intervals for the first 30 minutes, then every 15 minutes until the return of sensory block to L3 and motor block to modified Bromage score zero. The peak sensory level and time to reach were recorded using the pinprick test. Motor block was estimated with modified the Bromage scale [0 = no block – 1 = disability to raise the extended leg. 2 = disability to flex the Knee. 3 = disability to flex the knee and foot]. The maximum Bromage scale, time to reach, and time to regress to Bromage zero were related to the surgery was allowed to begin when the scale was 2 or 3.

All patients received normal saline [0.9% 5 ml/kg/h], and blood loss was replaced by blood. All patients received oxygen through a nasal catheter at a rate of two litters per minute.

Hypotension was assigned as systolic blood pressure < 90 mmHg or a decrease in mean arterial blood pressure by 20% of baseline and was controlled by 50 ug of phenylephrine, repeated three times if no response, norepinephrine was given at a rate 4-8 ug/min to maintain systolic blood pressure > 100 mmHg.

Bradycardia was assigned as a heart rate < 60 beat/minute and was controlled by 0.5 mg of atropine. If arrhythmias developed, they were managed by an amiodarone infusion.

After completion of surgery, surgery duration was recorded and 3 mL of 0.25% plain bupivacaine with 20 ug fentanyl was injected into the epidural catheter for postoperative analgesia before catheter removal. Patient satisfaction was assessed regarding pain or discomfort during surgery and in the post-operative period. Surgical satisfaction was also recorded regarding patient immobility and degree of muscle relaxation, patient was transferred to the ICU, where an ECG was recorded every 12 h and postoperative troponin was done daily for the next 3 days.

Outcomes

The primary outcomes included the evaluation of sensory and motor block characteristics including peak sensory level, time to reach peak sensory level, motor block by modified Bromage scale, time to maximum motor block, time for motor recovery to Bromage scale, and duration of block performance.

The secondary outcomes included the evaluation of hemodynamic changes [HR and MBP], incidence of side effects [hypotension, bradycardia, arrhythmias, neurological deficit, nausea, vomiting, pruritis, postoperative ECG Changes and postoperative troponin] and satisfaction of both surgeon and patient.

Sample size: The sample size calculation was performed using G. power 3.1.9.2 [Universität Kiel, Germany]. The sample size was calculated according to the time for motor recovery to MBS 1 [min], which was significantly faster in SE2 [5 mg of spinal bupivacaine + epidural 1.5% lidocaine 10 ml] group compared to SE1 [7.5 mg of spinal bupivacaine + epidural 1.5% lidocaine 10 ml] and S group [10 mg of spinal bupivacaine] [71.6 ± 42.9 vs. 125.5 ± 53.0 vs. 246.8 ± 86.6, P < 0.001, respectively], according to a previous study [7]. Based on the following considerations: 0.05 α error and 90% power of the study. Eight cases

were added to overcome dropout. Therefore, 60 patients were allocated.

Statistical analysis: The program used was SPSS version 20. Quantitative data were construed using mean and standard deviation, while frequency and percentage were used with qualitative data. Paired t tests and Friedman tests were used to compare differences in means at different time periods. The P value was deemed significant if it was 0.05

RESULTS

Our study was carried out on sixty adult cardiac patients, five of them [8.3%] with pulmonary hypertension [Systolic pulmonary artery pressure ≥ 50 mmHg] and fifty-five [91.7%] patients with depressed systolic function [EF $\leq 40\%$], who scheduled for lower body surgeries; 25 patients [41.6%] Orthopedic procedure, 20 patients [33.4%] for Urological procedures, 12 patients [20%] for surgical produces and 3 [5%] patients for obstetric procedures There were no difference in demographic

data of patients including ages body weight and height [Table 1].

Table 2 showed characteristics of block duration of surgery and block performance and total amount of fluid and vasopressors, 54 patients [90%] showed sensory block at T10 while 57 patients [95%] showed Bromage scale 3. Only 3 patients [5%] require Top-up doses and total dose of pheylephrine was 350 μ g.

There were no statistically significant changes in hemodynamics regarding heart rate and MBP throughout the procedure [Table 3].

Hypertension occurred in 5% of patients, bradycardia occurred in less than 2% of patients, no arrhythmia occurred in all patients, no post-operative ECG changes and postoperative troponin was negative [Table 4]. There was no postoperative nausea, vomiting, neurological deficit and pruritis [Table 4].

The satisfaction of the surgeons and patients was excellent [Table 5].

Table [1]: Demographic data and type of surgeries

Variables		Values
Gender, n [%]	Male	40 [66.7]
	Female	20 [33.3]
Age [years]	Mean \pm SD [range]	64.57 \pm 8.5 [39-84]
Weight [Kg]	Mean \pm SD [range]	77.37 \pm 10.31 [56-95]
Height [Cm]	Mean \pm SD [range]	171.9 \pm 7.3 [150-183]
Type of surgery, n [%]	Cemented bipolar hemiarthroplasty	12 [20.0]
	Subtrochanteric fracture fixation	8 [13.3]
	Total hip replacement	5 [8.3]
	Transurethral resection of prostate	16 [26.7]
	Transurethral resection of tumor	4 [6.7]
	Inguinal hernia with mesh	12 [20.0]
	Lower segment cesarean section	3 [5.0]

Table [2]: Characteristics of block, duration of surgery, duration of block performance and total amount of fluid and vasopressors

Variables		Values
Peak sensory level, n [%]	T8	6 [10.0]
	T10	54 [90.0]
Time to reach peak sensory level [min.]	Mean \pm SD [range]	8.77 \pm 1.47 [6-12]
Motor block by modified Bromage scale, n [%]	3	57 [95.0]
	2	3 [5.0]
Time to maximum motor block [min.]	Mean \pm SD [range]	9.9 \pm 1.49 [7.13]
Time for motor recovery to Bromage scale [min.]	Mean \pm SD [range]	119.1 \pm 25.39 [80-160]
Duration of block performance [min.]	Mean \pm SD [range]	6.87 \pm 1.43 [5-11]
Duration of surgery [min.]	Mean \pm SD [range]	113.02 \pm 34.78 [45-175]
Number of patients needed top up epidural, n [%]	Yes	3 [5.0]
	No	57 [95.0]
Total amount of fluid [ml]	Mean \pm SD [range]	752.5 \pm 117.68 [500-100]
Total vasopressor [phenylephrine] [ug]	Mean \pm SD [range]	26.18 \pm 5.83

Table [3]: Hemodynamic changes

		Baseline	5 min.	10 min.	15 min.	20 min.	30 min.	60 min.	120 min.	150 min.	P
HR	Mean	74.4	74.17	74.72	74.17	74.2	74.15	74.17	74.25	75.05	0.263
	±SD	4.54	4.65	5.27	4.6	4.79	4.74	4.56	4.62	4.37	
	Paired t-test		0.438	0.711	0.547	0.458	0.581	0.555	0.298	1.48	
	P1		0.66	0.48	0.587	0.648	0.563	0.581	0.767	0.15	
MBP	Mean	95.03	95.03	93.6	94.1	93.85	94.68	94.62	95.85	96.08	0.343
	±SD	7.64	7.64	7.79	7.53	7.72	7.33	7.08	7.19	6.91	
	Paired t-test		0.174	1.37	0.785	1.13	0.336	0.403	0.787	1.04	
	P1		0.863	0.175	0.385	0.264	0.738	0.689	0.435	0.303	

Table [4]: Incidence of side effects

Variables	Number of patients	%
Hypotension	3	5
Bradycardia	1	1.6
Arrhythmias	0	0
Neurological deficit	0	0
Nausea, vomiting	0	0
Pruritis	0	0
Postoperative ECG Changes	Negative	0
Postoperative troponin	Negative	0

Table [5]: Satisfaction of surgeon and patient

Variable	Number [%]
Surgeon	
Patient immobility	60 [100%]
Muscle relaxation	60[100%]
Overall satisfaction	60 [100%]
Patient	
Excellent	56 [93.3%]
Good	3 [5%]
Fair	1 [1.7%]
Poor	0 [0%]

DISCUSSION

The findings of our study show that sequential CSEA is a safe and effective technique for patients with significant cardiac disease undergoing lower body procedures. It also improved cardiovascular stability and was simpler to perform, which satisfied both surgeons and patients. In particular, for high-risk patients with compromised heart function, the technique permits titration of the local anaesthetic dose, allowing for safe anesthesia with gentle onset of sympathetic block and better control over the degree of sensory and motor blockade in accordance with surgical requirements.

Our study findings may be elucidated by the increase in cardiac output produced by a reduction in systemic vascular resistance and afterload as a result of limited sympathectomy caused by regional anesthesia with a small dose of local anaesthetic [8].

The principal anaesthetic management goals for patients with pulmonary hypertension or cardiomyopathy are maintenance of hemodynamic stability, forward flow, avoidance of volume overload, preservation of myocardial contractility, avoidance of myocardial depressants, avoidance

of afterload increase, maintenance of sinus rhythm, and avoidance of arrhythmias [9].

Spinal anesthesia with loss of sympathetic activity results in blood pooling in peripheral circulation, which lowers left ventricular end diastolic volume up to 19%, a causing reduction in cardiac output and hemodynamic instability particularly in patients with low ejection fraction who are mainly preload dependent, especially when spinal anesthesia is administrated as a single injection with a large local anaesthetic dosage [10].

Since sequential CSEA uses a small dose of local anaesthetics inducing less sympathetic blockade, it was anticipated that it would result in a smaller reduction in cardiac output and mean arterial blood pressure than single injection spinal anesthesia [11].

Vengamamba *et al.* [4] found that the combined spinal epidural approach is safer, more efficacious, and results in stable hemodynamics while providing longer analgesia with a small dose of intrathecal local anaesthetic in comparison with spinal anesthesia for high-risk geriatric patients enduring surgeries around the hip joint which supports our results.

Patients with left ventricular dysfunction have an increased incidence of deep venous thrombosis and pulmonary embolism, so regional anesthesia is preferred to general anesthesia in these patients, as the incidence of these complications is lower with regional anesthesia ^[12]. Regional anesthesia has many other advantages over general anesthesia, including the avoidance of stress responses with airway manipulation and intubation, reduction of afterload, improving cardiac outcome, a markedly decreased incidence of hypoxemia, pulmonary complications, intraoperative blood loss and post-operative confusion, as well as improved patients and surgeon satisfaction associated with rapid recovery ^[13].

In sequential CSEA, a small dose of spinal anesthesia is administered to decrease the incidence of hypotension and maintain hemodynamic stability, then a block extended cephalade with an epidural injection. The technique has the advantages of both spinal and epidural anesthesia as it allows rapid onset, reliable block, with a low drug dosage of spinal block with an epidural catheter in place, allowing titration, extending neuraxial block and providing postoperative pain control ^[14].

Besides averting many of their side effects, as an acute fall in blood pressure, being incapable of prolonging anesthesia [spinal], delayed onset and inadequate motor block [epidural]. The technique of low dose sequential CSEA, which combines the reliability of spinal anesthesia with the flexibility of an epidural catheter, is gaining increasing popularity for anesthesia in cardiac patients with low ejection fractions and high-risk geriatric patients where gradual onset sympathectomy is required to decrease hemodynamic variations ^[15].

In our study, we added 20 g of fentanyl to heavy Marcaine 0.5% in spinal anesthesia. It is now common practice to use opioids as an additive to local anaesthetics to enhance the sensory block of a small dose of local anaesthetic without affecting hemodynamics, as it doesn't increase the degree of sympathetic block ^[16]. This synergism is produced by different mechanism of drug action. Local anaesthetics act mainly by blocking axonal membrane voltage gated sodium channels ^[17]. While intrathecal opioids open potassium channels presynaptically, which inhibits the release of transmitters and so decreases calcium influx. This action inhibits afferent synaptic transmission through A-delta and C-fibers ^[18].

In this study, we used separate needle technique [SNT] with spinal anesthesia and epidural catheter placement performed at two different lumbar spaces, to reduce the risk of

inadvertent intrathecal migration of catheter and avoid delay in turning the patient supine after spinal anesthesia if there is difficulty in epidural catheter passage to get the best benefit of the initial low dose of spinal local anaesthetic. Besides, the success rate in SNT using double segments was higher in comparison with needle through needle technique [NTN]. In this technique, the epidural needle is sited and a fine gauge spinal needle is passed through it to perform subarachnoid block. The spinal needle is then withdrawn, and the epidural catheter threaded as reported by many previous studies ^[19].

Many explanations have been given as to how spinal extension occur after epidural top-up administration during CSEA ^[20]; epidural local anaesthetic leakage into subarachnoid space through dural hole, transdural spread of epidural local anaesthetic enhance existent subclinical analgesia into full strength analgesia, epidural space pressure is lower than pressure in cerebrospinal fluid once dural puncture occur equilibration occur, this change in epidural pressure may cause better spread of local anaesthetics through an effect on volume and circulation of CSF and thecal compression by epidurally injected volume of saline or local anaesthetics, causing CSF squeezing and more cephalade spread of spinal local anaesthetic. The magnitude of this volume effect depends on the time interval between the injections and the volume of epidural injectate, the delayed administration of epidural injectate beyond 10 minutes has been reasoned for frequent failure as shown by **Choi et al.** ^[21]. In our study, we injected epidural top-up earlier once the patient turned supine to keep the compression effect as a contributing factor for the extension of a low dose intrathecal local anaesthetic in the CSEA technique.

This result is in agreement with **Hamlyn et al.** ^[22] as they conclude that small dose sequential combined spinal epidural appears to be a safe anaesthetic technique for caesarean section in patients with significant cardiac disease. Moreover, **Atalay et al.** ^[23] conclude that small dose spinal anesthesia administered using combined spinal epidural technique is a suitable option for geriatric patient with aortostenosis undergoing lower extremity surgeries.

Joseph et al. ^[24] reported successful anaesthetic management of patients with pulmonary hypertension under general anesthesia is complex and challenging and regional anesthesia should be taken into consideration as it can decrease the need

for opioids and provide excellent relief to pain but should avoid significant hemodynamic changes.

Conclusion: Patients with significant cardiac disease undergoing lower body procedures, low dose sequential CSEA is a safe and effective approach that can be utilized as alternative to general anesthesia, epidural anesthesia and single shot spinal anesthesia. The CSEA technique achieved better hemodynamic and cardiovascular stability with a small dosage of local anesthetic.

Conflict of Interest: None.

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IJMA



INTERNATIONAL JOURNAL OF MEDICAL ARTS

VOLUME 6, ISSUE 6, JUNE 2024

P- ISSN: 2636-4174
E- ISSN: 2682-3780