CASE REPORT

Selective Spinal Anesthesia in a Patient with Low Ejection Fraction Who Underwent Emergent Below-Knee Amputation in a Resource-Constrained Setting

Hailemariam Mulugeta [ID]
Abebayehu Zemedkun [ID]
Hailemariam Getachew

Department of Anesthesiology, College of Medicine and Health Science, Dilla University, Dilla, Ethiopia

Abstract: Patients with congestive heart failure have a high risk of perioperative major adverse cardiac events and death. The major perioperative goal of management in patients with low ejection fraction is maintaining hemodynamic stability. Evidence is scarce on the safety of a certain anesthetic technique for patients with heart failure. In this report, we present a 48-year-old man with ischemic dilated cardiomyopathy and low-output congestive heart failure (estimated ejection fraction of 27%) who underwent emergent below-knee amputation under selective spinal anesthesia without any apparent complications. We believe that selective spinal anesthesia can be a useful alternative anesthetic technique in patients with low ejection fraction undergoing emergent lower limb surgery. We showed evidence-based and customized anesthetic management of a high-risk patient with the available equipment and resources. This report will hopefully show the contextual challenges of the perioperative care of critically ill patients in resource-constrained settings.

Keywords: congestive heart failure, low ejection fraction, dilated cardiomyopathy, neuraxial anesthesia, cardiovascular effects, spinal anesthesia spread, factors

Introduction

Congestive heart failure (CHF) is a major health burden, affecting 40 million people globally, and dilated cardiomyopathy (DCM) is one of its leading causes.[1,2] The number of patients with CHF presenting for surgery continues to rise, and anesthesiologists are responsible to provide safe perioperative care for patients with low ejection fraction (EF).[3] The risk of perioperative mortality and morbidity in patients with CHF is considerably high demonstrating the need for optimal perioperative management in these patients.[4,5]

Anesthetic goals in patients with low EF include maintaining forward flow and promoting inotropy. Pharmacologic agents, such as beta-blockers may be used perioperatively to achieve this goal. Nesiritide and levosimendan are popular new agents to optimize patients with acute CHF. Patients who are unresponsive to pharmacologic therapy will require assist devices, and others may even need extracorporeal membrane oxygenation.[3,6]

There is a paucity of evidence on the safety of a certain anesthetic technique for patients with CHF.[5] The key point is to avoid myocardial depression, maintain

Correspondence: Hailemariam Mulugeta
Department of Anesthesiology, College of Medicine and Health Science, Dilla University, PO Box 419/13, Dilla, Ethiopia
Tel +251 97 041 5208
Fax +251 46 331 0894
Email hmerry1990@gmail.com

hemodynamic stability, and meeting the requirements of surgery.[7] In this report, we present perioperative management of a patient with uncontrolled type II diabetes mellitus (DM) and CHF secondary to ischemic DCM with an estimated EF of 27%, and who had undergone emergent below-knee amputation under selective spinal anesthesia with a mixture of low dose bupivacaine, fentanyl, and dexmedetomidine. Our intention was to maintain hemodynamic stability and minimize other anesthesia-related perioperative side effects by controlling the spread of the spinal block so that only the nerve roots supplying the site of surgery are affected. This manuscript adheres to the applicable CARE case report guideline.

Case Description

A 48-year-old man (80 kg, 177 cm, and ASA PS-IV) was scheduled for emergent below-knee amputation after he was found to have left lower limb diabetic foot ulcer associated with whole foot gangrene and osteomyelitis. His medical history was significant for uncontrolled type II DM and New York Heart Association class IV stage C CHF secondary to ischemic 4-chamber DCM. Electrocardiography analysis showed sinus tachycardia, left axis deviation, left ventricular hypertrophy, and inferior myocardial infarction. Bedside examination of transthoracic echocardiography prior to surgery estimated left ventricular EF of 27% and noted minimal tricuspid regurgitation. Posteroanterior chest radiography revealed cardiomegaly with signs of left chamber enlargement and grade-2 pulmonary edema. Bilateral lower limb arterial duplex ultrasonography was suggestive of peripheral arterial disease with mild atherosclerotic changes. Other organ function and biochemical disturbances included mild hypokalemia, hypernatremia, hyperchloremia, hyperglycemia, and leukocytosis (Table 1). His medications on admission included NPH insulin, aspirin, atorvastatin, furosemide, and metoprolol. We estimated his subjective metabolic equivalent of tasks ≤4, revised cardiac risk index (Lee criteria) of >11%, and glomerular filtration rate of 21,518 mL/min/1.73m^2.

At admission to the operation theatre, he was diaphoretic with cold and clammy hands and feet. After informed consent, he was taken to the operating room where standard monitors were placed, and supplemental oxygen was administered via nasal cannula. A urinary catheter was placed to monitor urine output. The patient was then placed in a sitting position for spinal anesthetic administration.

Table 1 Summary of Preoperative Laboratory Results

Test Name	Result[a]	Reference	Unit of Measure
WBC	19.5	3.6–10.2	×10^3 cells/L
RBC	6.25	4.06–5.63	×10^6 cell/L
Hematocrit	39.0	36.7–47.1	%
Hemoglobin	13.1	12.5–16.3	g/dL
Platelet count	188	152–348	×10^3 cells/μL
ESR	13	0–30	mm/hour
HgbA1C	11.1	4.0–7.0	%
Rapid Blood Sugar	235	80–140	mg/dL
K$^+$	3.3	3.5–5.1	mmol/L
Na$^+$	182.3	135.0–155.0	mmol/L
Cl$^-$	113.2	98.0–111.0	mmol/L
Blood urea nitrogen	46	8–25	mg/dL
Creatinine	0.86	0.7–1.2	mg/dL
Urine Glucose (UGLU)	+2		mg/dL
Urine protein (UR PRO)	+1	Negative	mg/dL
Urine red blood cell (BLD)	+1	< 3	Cells/HPF
Urine WBC	5–10	≤4	Cells/HPF
Ketone	Negative		
High sensitive troponin test	0.104	≤14	ng/L

Notes: [a]These laboratory results were for a 48-year-old male patient with congestive heart failure, and type 2 diabetes mellitus who was admitted to operation theatre to undergo below-knee amputation for a diabetic foot ulcer under selective spinal anesthesia.
Abbreviations: WBC, white blood cell count; RBC, red blood cell count; ESR, erythrocyte sedimentation rate; HgbA1C, glycosylated hemoglobin; HPF, high power field.

The spinal block was performed by a consultant anesthetist between the level of L3 and L4 interspace using the midline approach. The skin was anesthetized with 3 mL of lidocaine 2%, and a 24-G Quincke spinal needle was used to administer a mixture of heavy bupivacaine 7.5 mg in 1.5 mL volume (BUPICAN™ HEAVY, 20mg/4mL ampule, Baxter Pharmaceuticals, India), dexmedetomidine 4 μg in 1 mL volume (Precedex™, 400 μg/100 mL vial, Hospira, USA), and fentanyl 25 μg in 0.5 mL volume (Fentanyl®, 100 μg/ 2 mL ampule, Janssen-Cilag Pharmaceutica, Germany). Phenylephrine, 50 μg, was administered intravenously, just before the subarachnoid block, as prophylaxis to postspinal hypotension. Immediately after the intrathecal injection, the patient was placed in the lateral position for 15 minutes, with the operative side down and the head 15°up. Then, he was turned supine and properly positioned for surgery. The sensory assessment revealed a loss of pinprick sensation to the level of T11 dermatomes and extending to both posteriorly and anteriorly.

Heart rate, oxygen saturation, and blood pressure were recorded before spinal anesthesia (baseline: mean blood pressure, MAP 87 mmHg; heart rate, HR 92 bpm; and S_p O2 at room air, 90%), just after spinal anesthesia, and then every 5 minutes till the end of surgery. Hemodynamic stability was maintained throughout surgery (ie, MAP, 75–92 mmHg; HR, 80–100 bpm; and average hourly urine output, 50 mL). His SpO_2 and skin temperature were maintained between 95% and 99%, and 36.0–36.8 °C, respectively. The rapid blood sugar test result at admission to operation theatre was 235 mg/dL. Intravenous regular insulin infusion (1unit/hour) was administered over an hour of the procedure, and the serum glycemic level was kept below 180 mg/dL. The surgical procedure was done by an orthopedic surgeon with 6 years of experience and lasted 80 minutes without any apparent complications. He received a total of 950 mL crystalloid and 350 mL packed red blood cells (PRBCs). The total estimated blood loss (EBL) was 350 mL, and the urine output was 150 mL. The patient was transferred to the postanesthesia care unit for further monitoring and then transported to the medical ward. He did not experience any side effects of perioperative therapy, including nausea, vomiting, pruritus, hypotension, or postdural puncture headache during his postoperative course. Postoperative laboratory exam on day one revealed hemoglobin, 12.1 g/dL; hematocrit, 35%; platelet, 185 $\times10^3$ cells/ μL; white blood cells, 15.6 $\times10^3$ cells/L; creatinine, 0.97 mg/dL; blood urea nitrogen, 42 mg/dL; K^+, 3.7 mmol/L; Na^+, 160 mmol/L; and Cl^-, 112.8 mmol/dL. He was discharged home on postoperative day 8 after the medical conditions were optimized.

Discussion

Heart failure is a high-risk disease with considerable perioperative morbidity and mortality demonstrating the need for careful assessment, optimization, and anesthesia planning for patients undergoing cardiac or noncardiac surgery.[5,8] Recent advances in cardiovascular anesthesia comprise advanced use of monitors, assist devices, and customized pharmacologic management.[8] When there is evidence of acute CHF in patients admitted for emergent surgery, the procedure should be postponed whenever possible until the cardiac function is compensated and hemodynamic stability is achieved.[4] On the other hand, there might be a time when patients are admitted on emergent basis and the risk of postponing the surgical procedure is overriding. Likewise, we encountered a case in which a patient with ischemic DCM with low-output CHF

admitted for emergent below-knee amputation for a life-threatening diabetic foot ulcer. The physical examination findings suggesting a low-output state preoperatively were inconclusive to presume that they were from preexisting heart failure and/or sepsis. Besides, one could argue that the patient should have been delayed until the blood sugar level is controlled. However, the medical team was not only concerned about a possible acute exacerbation of cardiopulmonary decompensation but also they were unable to control blood sugar associated with systemic septicemia.

There is a scarcity of data on the use of a certain anesthetic technique for patients with reduced EF.[5,6] In any surgical procedure involving low EF, maintaining hemodynamic stability, and even intraoperative survival become challenging issues. Efforts should be made to prevent intraoperative arterial hypotension and an inappropriately deep anesthesia level.[6,7]

The provision of anesthesia for patients with DCM undergoing non-cardiac surgery is challenging and is associated with high perioperative morbidity and mortality. The ventricular function, degree of myocardial fibrosis, and resting heart rate can affect survival rates. The goals of perioperative management in these sets of patients include focused preoperative assessment, close perioperative monitoring, suitable anesthetic, and maintaining hemodynamic stability. A thoracic epidural blockade may reverse myocardial fibrosis and improve ventricular function.[7] A retrospective study by Ituk et al also examined the successful use of combined spinal-epidural, epidural and general anesthesia in parturient with DCM.[9] In our case, we dictated that the patient would have an elevated risk of perioperative major adverse cardiac event, with an estimated revised cardiac risk index for noncardiac surgery of >11%, or death due to the combined cardiac and endocrine comorbidity. A team decision was made to perform the surgical procedure under SSA. Although the changes in outcome related to neuraxial anesthetic techniques in patients with cardiac disease are not clearly known,[6] epidural anesthesia may be advocated by many clinicians to achieve a more gradual and hemodynamically stable anesthetic. However, we did not have the privilege to provide it due to resource limitations.

Selective spinal anesthesia (also known as modified spinal anesthesia) can be achieved by using a reduced dose of local anesthetic plus adjuvants and by adopting maneuvers to control the spread of the block so that only the nerve roots supplying specific area are affected.

Unilateral lower limb block, lower torso block and saddle block are some of its variants. The technique is popular in day surgery, intending to incorporate patients with comorbidities who would otherwise be excluded.[10]

There is compelling evidence that adding adjuvants, such as opioids and α-2 agonists to a reduced dose of an intrathecal local anesthetics (LA) can decrease LA related adverse effects and prolong postoperative analgesia without compromising intraoperative anesthesia.[11–13] Having these experiences in mind, we conducted a modified spinal block using a mixture of low dose heavy bupivacaine (7.5 mg), dexmedetomidine (4 µg) and fentanyl (25 µg).

Dexmedetomidine, a highly selective α-2 receptor agonist, is found to have antinociceptive action when administered intrathecally. It was associated with prolonged motor and sensory spinal block and reduced the demand for rescue postoperative analgesics.[14] Fentanyl, on the other hand, is a highly lipophilic, potent µ-opioid receptor agonist that may fasten the onset of spinal block, prolong the duration of sensory block and reduce the analgesic requirement in the early postoperative period following its use as an additive to bupivacaine spinal anesthesia.[15] It is a daily clinical practice to use dexmedetomidine and fentanyl for spinal anesthesia without approval. Besides, the United States Food and Drug Administration recommends clinicians may prescribe a drug for off-label use when they determine that it is medically appropriate for their patients.[16] In our case, we used dexmedetomidine-fentanyl admixture with our prior knowledge that adding different adjuvants, with a varied mechanism of action, together would fasten the onset and quality of spinal anesthesia and decrease the dose requirement of LAs.

There is an increased demand for spinal anesthesia in high-risk patients with comorbidity dictating the continual search for drug combinations to improve perioperative anesthesia and analgesia while limiting side effects. The addition of dexmedetomidine plus fentanyl to bupivacaine intrathecally not only reduced the dose of an intrathecal LA requirement but also enhanced the duration of postoperative analgesia, and was not associated with hemodynamic instability.[11,13] On the other hand, dexmedetomidine added to hyperbaric bupivacaine intrathecally has a dose-dependent (5 µg versus 10 µg) favorable effect on the onset and regression of sensory and motor block.[17]

Spinal anesthesia-induced hypotension is one of the commonest immediate complications after the block due to arterial and venous vasodilatation resulting from the sympathetic block along with a paradoxical activation of cardio-inhibitory receptors. Fluid preloading with colloids or co-loading with crystalloid (or colloid) effectively reduces the incidence and severity of arterial hypotension. Phenylephrine or noradrenaline can be used to treat SAIH and as a prophylactic administration.[18] In our patient, the goal was to maintain the patient's baseline mean blood pressure (87 mmHg) by applying the principles of unilateral SSA, and we were successful. We did not intend to preload or co-load him for the spinal block with a fear of acute exacerbation of CHF. Only a single bolus of phenylephrine was administered as prophylaxis to postspinal hypotension just before the spinal block.

Our fluid management was empirical since we did not monitor the adequacy of organ perfusion directly. A slow transfusion of packed red blood cells diluted with crystalloids was started early after skin incision. The rate of infusions was adjusted based on the estimated blood loss, blood pressure, and urine output. Although our stated goal was euvolemia, one could claim that the patient was over-resuscitated by the end of the procedure, with 950 mL crystalloid and 350 mL PRBCs in as opposed to 350 mL blood loss and 150 mL urine output. However, we were concerned that insufficient preload due to hypovolemia could worsen his cardiac output. Moreover, any decrement in arterial blood oxygen was doubtful to be compensated by an increase in cardiac output since our patient had a negligible cardiac reserve.

Invasive blood pressure monitoring and goal-directed fluid therapy has been recommended in patients with CHF. The use of perioperative transthoracic or transesophageal echocardiography has been strongly recommended in patients at risk for acute exacerbation of CHF.[5,6] To date, the importance of filling pressure monitoring (central venous pressure and pulmonary artery pressure) is not well known but it was advised in patients with severe pulmonary hypertension and at risk of acute exacerbation of left ventricular dysfunction.[5] Invasive hemodynamic monitors were not used in our case due to resource constraints. Continuous electrocardiography (ECG) monitoring was used to detect ST-segment changes and identify the presence of myocardial ischemia. However, it is not clear if ECG monitoring is adequately sensitive to identify patients with myocardial ischemia.[6]

Conclusion

We present a case in which a patient with low EF underwent emergent below-knee amputation under modified spinal anesthesia. We claim that the successful conduct

of anesthesia, in this case, relies on a widespread appreciation of the clinical significance of adjuvants, such as opioids and α-2 agonists, mechanism of action of LAs, and adoption of the maneuvers to control the spread of the spinal block. We showed evidence-based anesthetic management of a high-risk patient with the available equipment and drugs in a low resource setting. We hope our report would be a very valuable educational experience showing the contextual challenges of perioperative care of critically ill patients in resource-constrained settings. We believe that selective spinal anesthesia can be a useful alternative anesthetic technique in patients with low-output heart failure undergoing emergent lower limb surgery. However, more evidence is required to determine the optimal combination of LAs and adjuvants for orthopedic procedures in high-risk patients.

Abbreviations

ASA PS-IV, American Society of Anesthesiologists Physical Status Class IV; CARE, CAse REport; CHF, Congestive Heart Failure; DCM, Cardiomyopathy; DM, Diabetes Mellitus; ECG, Continuous Electrocardiography; EF, Ejection Fraction; HR, Heart Rate; L3/L4, Third/Fourth Lumbar vertebrae; LA, Local Anesthetic; MAP, Mean Blood Pressure, NPH, Neutral Protamine Hagedorn; PRBCs, Packed Red Blood Cells; S_pO_2, Peripheral Oxygen Saturation; SSA, Selective Spinal Anesthesia.

Ethical Approval and Patient Consent

This case report has been exempted by the Institutional Review Board of Dilla University College of Medicine and Health Science from requiring ethical approval. Informed written consent was obtained from the patient to participate as well as to publish the data.

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Disclosure

The authors report no conflicts of interest in this work.

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