Original Article

Low-dose spinal block combined with epidural volume extension in a high-risk cardiac patient: A case-based systematic literature review

ABSTRACT

Background: Anesthetic management of patients with severe cardiac disease can be challenging during prolonged surgical procedures. Thus, alternative neuraxial anesthetic techniques have been described to avoid general anesthesia in these patients.

Methods: A case-based systematic literature review on low-dose spinal block combined with different methods of epidural block extension in high-risk cardiac patients was performed.

Results: We describe the successful management of a patient with poor left ventricular function who underwent excision arthroplasty of an infected hip prosthesis under low-dose spinal block with levobupivacaine 5 mg and fentanyl 15 μg combined with saline epidural volume extension (EVE). Epidural ropivacaine 0.75% was administered as a bolus of 5 ml followed by an infusion at 5 ml/h later during the course of surgery.

Conclusions: Although continuous spinal anesthesia (CSA) or epidural anesthesia may limit hemodynamic instability, the possibility of devastating central nervous system infection may prevent CSA use, and epidural block alone may be less reliable than CSA. Epidural block alone may require large volumes of concentrated local anesthetic to obtain sacral block, which may produce hemodynamic instability. The EVE, particularly using saline EVE, has rarely been described in high-risk cardiac patients as an alternative to CSA or epidural block alone, with the intention to avoid general anesthesia, but it has demonstrated efficacy and a low rate of complications. Hemodynamic stability was maintained in most cases.

Key words: Case-based literature review, epidural block extension, low-dose spinal block

Introduction

We describe the management of a high-risk cardiac patient who underwent excision arthroplasty of an infected hip prosthesis under low-dose spinal (LDS) block with levobupivacaine and fentanyl combined with saline EVE. Epidural ropivacaine was administered as a bolus and infusion later during surgery. Written consent for publication was obtained from the patient.

A case-based systematic literature review about the use of low dose spinal block combined with different methods of epidural block extension in high-risk cardiac patients was

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also performed. To our knowledge, a literature review has not been performed on this subject, particularly in high-risk cardiac patients.

We used a population, intervention, control, outcome, study design (PICOS) approach in a population of high-risk cardiac patients. The intervention was anesthesia for surgery expected to last more than an hour. There was no control group, and the outcomes included efficacy and complications of the technique, mainly hemodynamic stability. Our study design was based on a series of case reports.

Methods

Case-based systematic literature review

We conducted a systematic literature review with the use of LDS block and different methods of epidural block extension (using saline, local anesthetic, or saline combined further extension with local anesthetic) in high-risk cardiac patients for different surgical procedures.

We used a PICOS approach in a population of high-risk cardiac patients. The interventions included LDS block and different methods of epidural extension for surgical procedures expected to last more than an hour. There was no control group. We reviewed outcomes including efficacy and complications, mainly hemodynamic instability. We included series of case reports in our study design.

We searched PubMed by using the following combinations of terms: low-dose spinal AND epidural AND (cardiac OR heart OR cardiomyopathy)[*] ($n = 69$); combined with spinal epidural AND (cardiac or heart or cardiomyopathy)[†] ($n = 306$); epidural volume extension[**] ($n = 65$) [Figure 1]. The reference lists of retrieved articles included in the revision were checked to find other articles that matched the search criteria (two articles were considered). All the articles were published in Medline-indexed journals [Tables 1-3].

We included only full-text articles published in the English language. Case reports involving local anesthetic spinal dose superior to 8 mg of bupivacaine or levobupivacaine were not included. Case reports pertaining to labor analgesia were not included. Studies that used LDS block alone without concomitant epidural administration were not included. Case reports in which the epidural catheter was used only for postoperative analgesia were not included. Case reports in which only opioids were given through the spinal needle and the epidural block was the main anesthetic technique

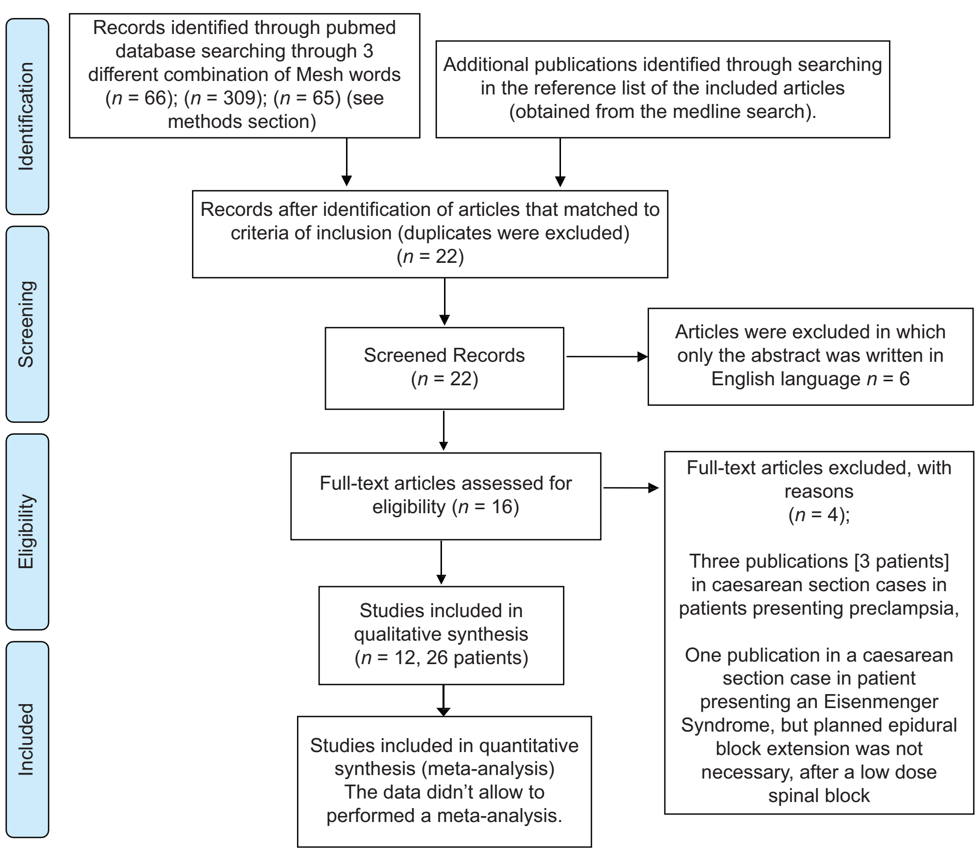

Figure 1: Prisma flow-chart showing the search method used to identify the included studies

Table 1: Reports of low-dose spinal blocks with saline epidural volume extension (without epidural local anesthetic supplementation) in high-risk cardiac patients

Authors	Description of the patients and surgical technique	Anesthetic technique	Outcome and complications
Tiwari AK *et al*.[1]	3 cases of cesarean section in patients with peripartum cardiomyopathy, 1 case of cesarean section in a patient having cardiomyopathy associated to Takayasu arteritis, 1 case of lower limb amputation, in a patient with ischemic cardiomyopathy. 1 case of emergent urinary clot evacuation in a patient with an ejection fraction <30% due to 3 episodes of myocardial infarction in the last 6 months	Spinal block (1 ml of ropivacaine 0,75% with 25 μg of fentanyl), plus 8 ml of saline EVE given 5 min after spinal bock	No hemodynamic instability was noted
Tiwari AK *et al*.[2]	Cesarean section in 5 patients suffering peripartum cardiomyopathy	Spinal block with hyperbaric bupivacaine 1ml of 0,5%. After 5 min: 8 ml of saline was given trough epidural catheter.	No hemodynamic instability was noted

Table 2: Reports of low-dose spinal blocks (without epidural volume extension) combined with local anesthetic epidural supplementation in high-risk cardiac patients

Authors	Description of the patients and surgical technique	Anesthetic technique	Outcome and complications
Gobbi *et al*.[3]	Renal transplantation in a patient with Alport syndrome	Spinal block with 4,5 mg of 0,5% hyperbaric bupivacaine plus continuous epidural infusion of 0,5% levobupivacaine mixed with 25μg of fentanyl at a rate of 8 ml/h.	No complications were observed.
Hamlyn EL *et al*.[4]	Cesarean section in:		
	1) patient suffering from restritive lung disease, cardiac heart failure, and secondary pulmonary hypertension aggravated by pregnancy;	1) Spinal block with 4 mg of hyperbaric bupivacaine and fentanyl 25 μg plus 3 ml and 2 ml of plain bupivacaine at 10 min and 15 min after the block (plus 150 μg of fentanyl) via epidural catheter.	1) No Complications
	2) patient with known hypertrophic obstructive cardiomyopathy and dilated atria; (delivery at 29 weeks)	2) Spinal block: hyperbaric bupivacaine 5 mg (1ml of 0,5%) and fentanyl 25 μg plus 4, 3, and 3 ml bolus of epidural 0,5% bupivacaine at 10, 20, 25 min after spinal block. Addition 10 ml of bupivacaine were given in divided doses.	2) 100 ug of Fentanyl IV were given after delivery. No vasopressors were needed.
Solanki SL. *et al*.[5]	Cesarean section in a patient with uncorrected Tetrology of Fallot	Spinal block with hyperbaric bupavacaine 2,5 mg (0,5 ml of 0,5%), plus epidural bolus of bupivacaine 0,5% (3 and 2 ml of bupivacaine given 10 and 20 min after spinal block) and fentanyl (100 μg). Prophylatic phenylephrine infusion was given before spinal	No significant hemodynamic changes were noted.
Indira K. *et al*.[6]	Cesarean section in a patient with peripartum myocardiopathy (EF <25%)	Spinal block with 5 mg of hyperbaric bupivacaine (1m of 0,5%) and fentanyl 20 ug plus epidural increments of lidocaine 2% (2+2 ml).	No complications
Shnaider R *et al*.[7]	Cesarean section in a patient with peripartum cardiomyopathy	Spinal block with 6 mg of hyperbaric bupivacaine (0,8 ml of 0,75%) and fentanyl 15 ug plus epidural increments of lidocaine 2% (2+2 ml).	No complications
Pirlet M *et al*.[8]	Cesarean section in a patient with peripartum cardiomyopathy	Spinal block with 5 mg of hyperbaric bupivacaine (0,5%) and diamorphine 0,3 mg plus epidural 10 ml of bupivacaine 0,5% given after the spinal block	Reduction in heart rate and hypotension after spinal and tachycardia after delivery.
Liao Z *et al*.[9]	Cesarean section in a patient with uncontrolled hyperthyroidism and thyrotoxic heart disease.	Spinal anesthesia with 7.5 mg of 0.5 % bupivacaine plus, fifteen minutes later, two doses of 3 ml 2% lidocaine at 5-min through the epidural catheter.	Opioids were given intravenously to the mother for sedation after delivery of the baby. Satisfactory anesthesia and sedation was provided during surgery. No complications were noted.
Chen L-K *et al*.[10]	Caesarean section in 3 patients with severe pulmonary hypertension induced by Ritodrine	Spinal anesthesia with 4 mg of 0.5 % hyperbaric bupivacaine (diluted up to 3 ml with normal saline) plus, 3 doses of 3 ml 2% lidocaine given intermittently through the epidural catheter to reach a sensory block level of T5, with a Bromage score of 1 to 2 points.	All the patients developed hypotension that was successfully treated with bolus ephredine (8 mg) in 2 cases but in was case an continuos infusion of epinephrine was indicated.

were also excluded. After exclusion of duplicates, 12 papers were included with a total of 26 patients. Patients with pre-eclampsia who underwent caesarean section were not included because no data was available on cardiac function (three reports).

Seven reports (13 patients) were obtained through Medline search.

Risk of bias: Unsuccessful cases may not have been published (publication bias).

Table 3: Reports of low-dose spinal blocks with epidural volume extension (EVE) combined with local anesthetic epidural supplementation in high-risk cardiac patients

Authors	Description of the patients and surgical technique	Anesthetic technique	Outcome and complications
Hamlyn EL *et al*.[4]	Cesarean section in:		
	1) patient suffering from aortic stenosis and coronary disease;	1) Spinal Block with hyperbaric bupivacaine 5 mg and fentanyl 25 μg plus 5 ml of saline EVE via epidural needle, and epidural bolus of bupivacaine 0,5% with epinephrine 5 μg/ml (1 + 1 ml), and plain bupivacaine 0,5% (1ml) after the spinal block.	1) After delivery systolic arterial pressure was <70 mmHg and a total of 300 μg of phenylephrine were needed.
	2) patient suffering from severe mitral stenosis	2) Spinal Block with hyperbaric bupivacaine 5 mg and fentanyl 20 μg plus 5 ml of saline EVE via epidural needle, and epidural three 2ml bolus of bupivacaine 0,5% and fentanyl 25 μg given during surgery (45 min)	2) No complications
Agarwal A *et al*.[11]	Hysterectomy in patient with unpalliated cyanotic heart disease	Spinal Block with hyperbaric bupivacaine 5 mg and fentanyl 25 μg plus 6 ml of saline EVE via epidural needle 5 minutes later. 30 min later, 5 ml of epidural bupivacaine 0,5% and fentanyl 25 μg were given.	No complications
Srivastava VK *et al*.[12]	Renal transplantation in a patient with uremic cardiomyopathy (Ejection fraction 25%).	Spinal Block with hyperbaric bupivacaine 7,5 mg and fentanyl 25 μg plus 10 ml of saline EVE via epidural catheter, plus epidural bolus of 5 ml of bupivacaine 0,5% 90 min after spinal block.	No complications

Results

Data from case report

An 80-year-old woman, classified as American Society of Anesthesiologists (ASA) class IV, was scheduled for excision arthroplasty of an infected hip prosthesis. Her comorbidities included congestive cardiac failure (New York Heart Association class III symptoms), obesity, and type II diabetes mellitus. She had type I respiratory failure (PaO_2 of 58 mm Hg and $PaCO_2$ of 43 mm Hg on air) and anemia (Hg 10.2 g/dl). Her functional capacity was less than 4 metabolic equivalents of task, and she was admitted to the intensive care unit 6 months previously with cardiogenic shock against a background of complicated cholecystitis. Her left ventricular ejection fraction during that admission was 20%, and she needed inotropic support with a levosimendan infusion as part of intensive care management. Her preoperative evaluation during the current admission revealed a left ventricular ejection fraction of 38%. Previous echocardiography had shown moderate aortic stenosis and mild mitral stenosis. She had leukocytosis (white blood cell count: 16×10^9/l) and mild elevation of C-reactive protein elevation but was apyretic.

Considering the risks of a standard dose of spinal anesthesia, a continuous spinal block or general anesthesia, and the likelihood of an ineffective epidural block, we administered a LDS block with saline EVE combined with supplemental epidural anesthesia. The presence of an abscess did not permit a fascia iliaca or femoral block. A posterior lumbar block may have caused significant hemodynamic instability in this patient.

After establishing monitoring according to ASA standards, two large-bore intravenous lines were placed, and invasive arterial pressure monitoring was commenced. This was followed by administration of 0.1 mg of fentanyl and 1 mg of midazolam intravenously, followed by 500 ml of ringer's lactate solution. Intravenous ceftriaxone 1 gm was administered and the urine output was monitored throughout surgery.

Skin infiltration was carried out with 5 ml of 2% lidocaine, with the patient in the right lateral position. Epidural puncture was performed by the midline approach at the L3-L4 interspace by using the loss of resistance to air technique with a combined spinal-epidural (CSE) device (Espocan® B. Braun Melsungen, Germany). Following this, a 27-G spinal anesthesia needle was introduced through the Tuohy needle, and after reflux of cerebrospinal fluid, spinal block was carried out. An LDS block was done using levobupivacaine (1.5 ml of 0.375%) and fentanyl (15 μg). The spinal needle was then removed and an epidural catheter was inserted while the patient continued to be in the lateral decubitus position. The subarachnoid injection produced a unilateral sensory block up to T10 within 12 min. Before the commencement of surgery and 15 min after the spinal injection, 8 ml of saline was given through the epidural catheter. A maximum sensory level of T8 was achieved after EVE. An epidural infusion of 0.75% ropivacaine infusion (5 ml/h), after a bolus of 5 ml, was commenced 40 min after the spinal block and continued until 15 min before the completion of surgery. The level of sensory block was maintained at T10 after commencement of the epidural infusion. A low-dose propofol (1%) infusion at 100 mg/h was maintained to achieve conscious sedation throughout surgery. Surgery was performed in the lateral decubitus position.

The patient remained hemodynamically stable during administration of the neuraxial anesthesia. Only when hemorrhage was maximal during surgery (30 min after commencement of the epidural infusion), a low-dose infusion of intravenous phenylephrine was needed to normalize arterial blood pressure (total consumption: 0.5 mg). The total estimated blood loss was 600 ml; two units of packed red cells and 2000 ml of crystalloid solution were administered intraoperatively. Aminocaproic acid was administered before incision as a bolus dose of 5 gm, followed by an infusion of 1 gm/h and continued until 2 h after surgery. Before closure of the surgical incision, we administered metamizol 2 gm, paracetamol 100 mg, tramadol 100 mg, and ondansetron 4 mg intravenously.

At the completion of surgery, 3 h after the spinal block, the sensory level had regressed to T12 bilaterally. At this stage, 1.5 mg of epidural morphine was administered.

On admission to the post-anesthesia care unit (PACU), the patient was able to move her feet and 10 min later she was able to flex her knees. The epidural catheter was removed in the PACU because of the risk of infection. In the PACU, after resolution of the neuraxial block, the patient was hypotensive, which required frequent phenylephrine boluses. A total dose of 1.4 mg was administered during the first 6 h in the PACU. The hematocrit remained stable (Hb 10.5 g/dl) with a urinary output of 1–2 ml/h with no signs of hypovolemia or blood loss. No rescue analgesia was required in the PACU. The patient was discharged to the ward 6 h after admission to the PACU.

In the ward, the arterial pressure was maintained at basal levels. The intensity of pain on the numerical rating scale was less than 3 in the postoperative period, with intravenous administration of paracetamol 1 gm 8-hourly, metamizol 2 gm 12-hourly, and tramadol 50 mg 8-hourly.

Data from case-based literature review

Low-dose spinal block plus saline epidural volume extension[1,2]

LDS block plus saline EVE without epidural local anesthetic supplementation has been reported in 11 high-risk patients (nine cases of cesarean section, a case of urinary clot evacuation, and a case of lower limb amputation) without significant hemodynamic changes [Table 1].

Low-dose spinal block combined with epidural local anesthetic supplementation[3-10]

Eight cases have been reported in high-risk cardiac patients—seven for cesarean sections, and one for renal transplantation—using LDS block without EVE combined with epidural local anesthetic supplementation [Table 2].[4-8] All cases were managed successfully but in 4 cases some degree of hemodynamic instability was reported.

Low-dose spinal block with saline epidural volume extension combined with epidural local anesthetic supplementation[4,11,12]

Only four cases have been described using a technique similar to ours in high-risk cardiac patients [Table 3]. All were managed successfully; however, a decrease in systolic arterial pressure was noted after delivery of the baby during a cesarean section.

Among the 26 cases reported so far, 21 were performed in obstetric anesthetic practice. Only two cases have been reported for unilateral surgery performed in the lateral decubitus position (renal transplantation under LDS block combined with epidural supplementation, with and without saline EVE). A case of lower limb amputation has also been reported; however, the surgery was performed in the supine position.

Discussion

General anesthesia may lead to dose-related cardiovascular depression, arrhythmia, and congestive cardiac failure in patients with poor left ventricular function. Spinal anesthesia is a widely used anesthetic technique for hip surgery in the elderly but carries the risk of severe and prolonged dose-dependent hypotension, particularly in high-risk cardiac patients.[13,14] Spinal anesthesia may also lead to intense hemodynamic instability secondary to sympathetic block. The risk of failure of single-dose LDS exists, particularly in case of prolonged hip surgery, because of the limited duration of action of a low-dose spinal block.[15]

Epidural anesthesia alone may be an option, but it is associated with patchy sensory block and frequently spares the sacral roots. Thus, a high volume of a concentrated epidural solution of local anesthetics is required to produce a dense block of the hip region, which can produce a high bilateral block and concomitant hemodynamic instability.

CSA is of particular interest in patients with respiratory or cardiac disease. It may minimize the block of respiratory muscles and reduce the incidence of hypotension. Furthermore, prolonged surgery may be performed when the risks of general anesthesia are considered too high. It has been reported to result in effective sensory-motor blockade with fewer hemodynamic changes. However, CSA has been implicated in specific complications including infection, headache, and the cauda-equina syndrome.[16]

Theoretically, CSA may have advantages over LDS block combined with epidural supplementation, including less use of local anesthetic and the tendency to produce a predominantly unilateral block throughout surgery. This is more prominent with hypobaric solutions with the patient maintained in the lateral decubitus position throughout surgery. However, we felt that the risk of infection with intrathecal catheterization was very high in our patient. Thus, considering the increased risk associated with general anesthesia, we opted for a low-dose spinal with a hypobaric solution with saline EVE combined with epidural supplementation using ropivacaine. We believe that with CSA, there is a higher probability of devastating central nervous system infection, with a faster onset and fewer treatment options.[17]

In the practice of obstetric anesthesia, CSE has been widely studied to increase the quality of anesthesia or analgesia and to minimize complications. CSE may also increase patient safety in labor analgesia or anesthesia for cesarean section in high-risk patients. Apart from obstetric anesthetic practice, CSE alone has been successfully described in patients with severe chronic obstructive pulmonary disease (COPD) for various procedures including open abdominal aortic aneurism repair surgery.[18] A case of sigmoid colectomy in a patient with COPD and congestive heart disease using CSE has also been described;[19] however, reports of LDS with or without saline EVE combined with epidural supplementation are uncommon in high-risk cardiac patients, particularly in prolonged lateral decubitus surgery.

In elderly patients, Tahtaci N *et al*.[20] showed that EVE with 10 ml saline 15 min after a spinal block using 5 mg bupivacaine and 12.5 µg fentanyl resulted in a higher level of block compared to subarachnoid block with 10 mg bupivacaine and 25 µg fentanyl. EVE with spinal block resulted in adequate anesthesia, with fewer complications.

Several studies have demonstrated that EVE compresses the dural sac as a result of a rise in pressure in the epidural space. This effect is time-dependent and during prolonged surgery, epidural local anesthetic supplementation must be administered.[21] Saline EVE contributes to the feasibility and safety of LDS block. It potentiates the effect of an initial low dose spinal dose allowing an adequate proximal level of blockade, reducing the need to place a spinal catheter for titration of LA administration and minimizing hemodynamic side effects of standard spinal dose. Moreover, compared to EVE using local anesthetics, it reduces the risks of hemodynamic instability of early epidural local anesthetic supplementation after spinal block. We did not observe any dilutional effect of epidural supplementation due to previous saline EVE in the present case. A spinal block using a standard dose must be avoided because early EVE carries the risk of a high spinal block.

Given the increasing life expectancy of patients with poor cardiac function, the need for alternative methods of providing prudent and safe anesthesia is paramount, particularly to avoid significant hemodynamic instability during emergent cases. Surprisingly, to our knowledge, there is no report in the literature using LDS combined with saline EVE and epidural supplementation in prolonged hip surgery with the potential for severe hemorrhage.

We believe that the advantages of this alternative approach may be potentiated in high-risk cardiac patients during prolonged unilateral surgery performed in the lateral position. This technique involves the use of hypobaric spinal solutions for complex hip surgery being maintained lateral decubitus position after the spinal block.

A lower spinal dose, particularly with saline EVE, will be more effective and lead to a longer duration of action in surgery performed in the lateral decubitus position. Epidural local anesthetic supplementation can be commenced at a later stage during the surgery and thus being safer.

Limitations: The quality of evidence is low because the extracted data are from isolated case reports or case series. This fact was expected due to the heterogeneity of the very high-risk cardiac population, preventing the performance of trials. Nonetheless, it seems important to have an overview of the cases/series of cases published to date.

Conclusion

In conclusion, despite the risks of neuraxial contamination, combined low-dose spinal with saline EVE and local anesthetic epidural supplementation was used as an alternative to CSA or epidural alone because the risks of GA were considered to be high in this case. The various techniques described in this literature review led to a successful and reliable anesthetic procedure in high-risk cardiac patients.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given her consent for her images and other clinical information to be reported in the journal. The patient understand that her names and initials will not be published and due efforts will be made to conceal their identity and grant anonymity of the case details.

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Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Tiwari AK, Singh RR, Anupam RP, Ganguly S, Tomar GS. Epidural volume extension: A novel technique and its efficacy in high risk cases. Anesth Essays Res 2012;6:233-5.
2. Tiwari AK, Agrawal J, Tayal S, Chadha M, Singla A, Valson G, *et al*. Anesthetic management of peripartum cardiomyopathy using "epidural volume extension" technique: A case series. Ann Card Anaesth 2012;15:44-6.
3. Gobbi F, Sales G, Bretto P, Donadio PP, Brazzi L. Low-dose spinal block with continuous epidural infusion for renal transplantation in a patient with Alport syndrome: A case report. Transplant Proc 2016;48:3067-9.
4. Hamlyn EL, Douglass CA, Plaat F, Crowhurst JA, Stocks GM. Low-dose sequential combined spinal-epidural: an anaesthetic technique for caesarean section in patients with significant cardiac disease. Int J Obstet Anesth 2005;14:355-61.
5. Solanki SL, Jain A, Singh A, Sharma A. Low-dose sequential combined-spinal epidural anesthesia for Cesarean section in patient with uncorrected tetrology of Fallot. Saudi J Anaesth 2011;5:320-2.
6. Indira K, Sanjeev K, Sunanda G. Sequential combined spinal epidural. Anaesthesia for caesarean section in peripartum cardiomyopathy. Indian J Anaesth 2007;51:137-9.
7. Shnaider R, Ezri T, Szmuk P, Larson S, Warters RD, Katz J. Combined spinal-epidural anesthesia for Cesarean section in a patient with peripartum dilated cardiomyopathy. Can J Anesth 2001;48:681-3.
8. Pirlet M, Baird M, Pryn S, Jones-Ritson M, Kinsella SM. Low dose combined spinal-epidural anaesthesia for caesarean section in a patient with peripartum cardiomyopathy. Int J Obstet Anesth 2000;6:189-92.
9. Liao Z, Xiong Y, Luo L. Low_dose spinal—epidural anesthesia for Cesarean section in a parturient with uncontrolled hyperthyroidism and thyrotoxic heart disease. J Anesth 2016;30:731-4.
10. Shin-Yan C, Shou-Zen F, Li-Kuei C. Ultralow dose combined spinal-epidural anesthesia for cesarean section in ritodrine-related severe pulmonary hypertension. Taiwanese J Obstetrics & Gynecology 2013;52:617.
11. Agarwal A, Garg R, Joshi A, Verma S. Combined spinal epidural anesthesia with epidural volume extension technique for hysterectomy in patient with unpalliated cyanotic heart disease--A case-report. Acta Anaesthesiol Belg 2010;61:159-61.
12. Srivastava VK, Agrawal S, Das PK, Ahmed M. Low dose spinal with epidural volume extension for renal transplantation in a patient with uremic cardiomyopathy. Indian J Anaesth 2014;58:93-4.
13. Ben-David B, Miller G, Gavriel R, Gurevitch A. Low-dose bupivacaine-fentanyl spinal anesthesia for cesarean delivery. Reg Anesth Pain Med 2000;25:235-9.
14. Van de Velde M, Van Schoubroeck D, Jani J, Teunkens A, Missant C, Deprest J. Combined spinal-epidural anesthesia for cesarean delivery: Dose-dependent effects of hyperbaric bupivacaine on maternal hemodynamics. Anesth Analg 2006;103:187-90.
15. Favarel-Garrigues JF, Sztark F, Petitjean ME, Thicoipe M. Lassie P, Dabadie P. Hemodynamic effects of spinal anesthesia in the elderly: single dose versus titration through a catheter. Anesth Analg 1996;82:312-6.
16. Moore JM. Continuous spinal anesthesia. Am J Ther 2009;16:289-94.
17. Grewal S, Hocking G, Wildsmith JAW. Epidural abscesses. Br J Anaesth 2006;96:292-302.
18. Flores JA, Nishibe T, Koyama M, Imai T, kudo F, Miyazaki K, *et al*. Combined spinal and epidural anesthesia for abdominal aortic aneurysm surgery in patients with severe chronic pulmonary obstructive disease. Int Angiol 2002;21:218-21.
19. Morton G, Bowler I. Combined spinal-epidural as an alternative method of anaesthesia for a sigmoid-colectomy. Anaesthesia 2001;56:815-6.
20. Tahtaci N, Neyal M. Combined spinal and epidural anaesthesia in elderly patients. Int J Clin Pract 2002;56:655-8.
21. McNaught AF, Stocks GM. Epidural volume extension and low-dose sequential combined spinal-epidural blockade: Two ways to reduce spinal dose requirement for caesarean section. Int J Obstet Anesth 2007;16:346-53.