

Use of Dexmedetomidine and Esmolol for Hypotension in Lumbar Spine Surgery

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Abstract

Background: The importance of decreasing bleeding in spine surgery is not only important to maintain the patient's hemodynamic balance but also allow a better view of the surgical field.

Objectives: The current study aimed to compare dexmedetomidine and Esmolol™ as agents to induce hypotension in lumbar spine surgeries.

Patients and Methods: A total of 50 patients aged 20 to 65 years belonging to the American society of anaesthesiologist (ASA) class I - II scheduled for decompression and fixation of the lumbar spine were included and divided into two groups namely, Group I, who received Esmolol and group II, who received dexmedetomidine, intravenously. The patients were compared for intraoperative hemodynamic parameters, estimated blood loss, operation time, intraoperative analgesic (fentanyl) consumption, and total fall in haemoglobin (Hb) during the perioperative period.

Results: The study results showed that dexmedetomidine had lower (100.8 µg) fentanyl and sevoflurane consumption (1.2%), and less blood loss (278 mL) in comparison to the Esmolol group.

Conclusions: Both dexmedetomidine and Esmolol can be used as agents to control hypotension in patients undergoing lumbar spine decompression and fixation surgery; the dexmedetomidine group, however, was associated with better intraoperative hemodynamic stability and reduced intraoperative analgesic and volatile anaesthetic requirement.

Keywords: Dexmedetomidine, Esmolol, Induced Hypotension, Sevoflurane, Spine Decompression and Fixation

1. Background

The importance of decreasing bleeding in spine surgery is not only important to maintain haemodynamic stability, but also to improve the view of surgical field that harbors major and highly fragile neurologic structures (1).

Various agents are used to provide a controlled hypotension including direct acting vasodilators (sodium nitroprusside, nitroglycerin), ganglion-blocking agents, beta adrenergic blockers (Esmolol™), calcium channel blockers (nicardipine), alpha-2 agonists (clonidine, dexmedetomidine (DEX) and magnesium sulphate (2, 3). The central and peripheral sympatholytic action of DEX is mediated by alpha-2 adrenergic receptors and manifested by dose-dependent decrease in arterial blood pressure, heart rate (HR), and hence is used as an agent to induce hypotension (4, 5). Esmolol is a short acting beta adrenergic receptor antagonist that decreases the HR and blood pressure. It is used as an agent to control hypertension

and induce hypotension (6, 7).

2. Objectives

The current study aimed to compare DEX and Esmolol infusions as agents for hypotensive anaesthesia in lumbar spine decompression and fixation surgeries; intraoperative hemodynamic parameters, estimated blood loss (EBL), operative time, intraoperative analgesic (fentanyl) consumption, and total fall in haemoglobin (Hb) during perioperative period were assessed.

3. Patients and Methods

This study was conducted in Artemis health institute from April 2013 to February 2014. A total of 50 patients, aged 20 to 65 years, with American society of anaesthesiologist (ASA) class I - II, scheduled to undergo decompression and fixation of the lumbar spine were studied. Pa-

tients were randomly allocated into two groups of 25, by computer generated random table method. Informed consent was obtained from each patient included in the study and the study protocol conformed to the ethical guidelines of the Helsinki declaration as reflected in a prior approval by the human research ethics committee (HRECs). Patients in Group I received Esmolol and Group II received dexmedetomidine, intravenously.

Patients with a history of cardiac diseases (uncontrolled hypertension, second and third degree heart block, unstable angina pectoris), pre-existing coagulopathy, hepatic or renal dysfunction, poorly controlled asthma, neuromuscular disorders, seizure disorder, patients receiving beta blockers, or allergy to any of the used drugs were excluded from the study.

3.1. Preanaesthetic Preparation

All the patients were hospitalized a day before surgery and kept fasting for at least six hours before surgery. Anaesthesia was standardized, consisting of glycopyrrolate (0.2 mg) and ranitidine (50 mg) as premedication intravenously 30 minutes before induction and standard monitors, electrocardiography (ECG), non-invasive blood pressure amplifier (NIBP) and SpO₂ were used in the operating room. A 20-G cannula was inserted into a radial artery to direct measurement of arterial blood pressure recorded continuously. Urinary catheter was put after induction to measure urine output.

3.2. Anaesthesia

After pre-oxygenation with 100% oxygen for three minutes, anaesthesia was induced with fentanyl (1 µg/kg) and propofol (2 - 2.5 mg/kg IV) and IV vecuronium (0.1 mg/kg) was used to facilitate tracheal intubation. Anaesthesia was maintained with oxygen, nitrous oxide and sevoflurane and mechanically ventilated with a tidal volume of 10 mL/kg, a respiratory rate adjusted to maintain end-tidal carbon dioxide (ETCO₂) concentration of 30 - 35 mmHg (10 - 16 breaths/minute). All patients were then placed prone with the chest and pelvic rolls, leaving the abdomen hanging free, with all pressure points well padded. Sequential pneumatic inflation pump for prophylaxis of deep venous thrombosis was applied to lower limbs. All patients were operated by the same surgery team. Patients in Group I received Esmolol 0.5 mg/kg/minute about one minute before induction later titrated to 10 - 200 µg/kg/minute as per effect; and patients in Group II received dexmedetomidine 1 µg/kg 10 minutes before induction followed by maintenance rate of 0.4 - 0.7 µg/kg/hour. Both of the infusions were titrated intraoperatively to maintain mean arterial pressure (MAP) between 60 - 65 mmHg. Before surgery commenced, the incision site was infiltrated

with 10 millilitres of 2% lignocaine, containing 1:200 000 epinephrine. Intraoperative fluids administered for all patients included ringer lactate as a maintenance fluid and normal saline for deficits and losses including packed red blood cells (RBCs) transfusion for blood loss to a threshold of haemoglobin of 7 mg/dL and haematocrit of 25% - 30% were administered. The intraoperative estimated blood loss (EBL) for each procedure was calculated by weighing the surgical gauze pads and measuring the contents of the suction bottle (with adjustment made for the amount of saline irrigation used). Haemoglobin (Hb) level and haematocrit value were postoperatively compared with preoperative values. Signs of inadequate anaesthesia (e.g. increases in MAP greater than the target level) were treated with additional IV boluses of fentanyl in a dose of 1 µg/kg and recorded. Nitroglycerine was infused as a rescue hypotensive agent if these target levels could not be achieved with the uppermost dose. The primary endpoint was MAP 60 - 65 mmHg before skin incision in both groups, while secondary endpoints included: occurrence of tachycardia, the need to use rescue hypotensive agent, and recovery time.

MAP below 55 mmHg was considered hypotension and HR below 45 beats/minute as bradycardia and treated with ephedrine 5 mg and atropine 0.5 mg, respectively.

Infusion of the study drugs was stopped 10 minutes before the anticipated end of surgery. At the end of surgery residual neuromuscular blockade was reversed with neostigmine and glycopyrrolate. After complete recovery from anaesthesia, patients were transferred to the recovery room.

The two groups were then compared with reference to patient characteristics, intraoperative clinical data (intraoperative hemodynamics, estimated blood loss, intraoperative fentanyl consumption) and total fall in Hb during the perioperative period. Patients with uncontrolled hemodynamics were excluded from the study.

3.3. Statistical Analysis

The response within each group was normally distributed with standard deviation 2. It was necessary to study a minimum 22 experimental subjects in each group to reject the null hypothesis (that the population means of the experimental groups are equal with probability of 0.8).

Data were analysed using SPSS. Numerical data were expressed as mean ± SD. Comparison between the two groups was done using parametric or non-parametric T-test. Intra group comparison relative to baseline was performed using repeated measure analysis of variance (ANOVA). P value < 0.05 was considered significant.

4. Results

The two groups did not differ preoperatively with respect to age, weight, gender, and hemodynamic parameters (Table 1).

Table 1. Demographic Data and Operative Parameters

Demographic Data and Baseline Operative Parameters	Group I (Esmolol™)	Group II (Dexmedetomidine)	P Value
Age, y	58.58 ± 6.12	51.15 ± 8.88	0.52
Weight, kg	64.58 ± 8.84	69.7 ± 5.33	0.54
Gender			0.75
Male	12	12	
Female	3	3	
SBP, mm Hg	123.04 ± 7.85	118.7 ± 5.89	0.735
DBP, mm Hg	71.79 ± 6.10	74.9 ± 5.48	0.661
PR, min	75.29 ± 6.92	79.6 ± 4.42	0.544

Abbreviations: DBP, diastolic blood pressure; PR, pulse rate; SBP, systolic blood pressure.

There was a significant reduction in volatile anaesthetic and fentanyl consumption in DEX group compared to those of the Esmolol group. Total fentanyl consumption in Esmolol group was 180.8 ± 18.7 µg and 100.8 ± 8.9 µg in DEX group (P = 0.002). Total sevoflurane concentration used in Esmolol group was 2.2 ± 0.2% and in DEX group it was 1.2 ± 0.5% (P = 0.04) (Figure 1).

Total intraoperative blood loss in the Esmolol and DEX groups were 308.3 ± 47.5 and 277.8 ± 8.9 mL and perioperative fall in Hb were 1.9 ± 0.6 and 1.7 ± 0.5 g/dL respectively, however it was not statistically significant (P > 0.05) (Figure 2).

Intraoperative mean arterial blood pressure (MAP) and heart rate (HR) were lower in the dexmedetomidine group as compared to those of the Esmolol group. The intraoperative MAP and HR were 68.9 ± 3.5 mmHg and 61 ± 3.5 beats per minute (BPM) in Esmolol and 60.2 ± 1.9 mmHg and 56.1 ± 1.5 BPM in DEX groups, respectively (P < 0.05) (Table 2).

Table 2. Intraoperative Parameters

Intraoperative Parameters	Group I (Esmolol)	Group II (Dex)	P Value
MAP, mmHg	68.875 ± 3.45	60.2 ± 1.88	0.02
HR (BPM)	61 ± 3.452	56.1 ± 1.45	0.04

Abbreviations: BPM, beats per minute; DEX, dexmedetomidine; HR, heart rate; MAP, mean arterial pressure; mmHg, millimetres of mercury.

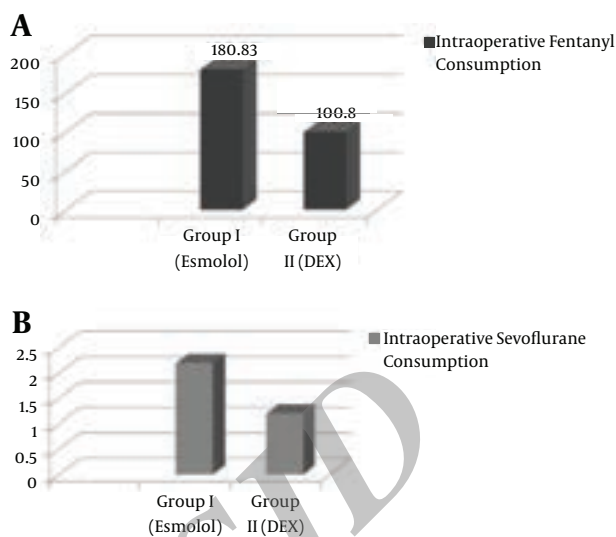


Figure 1. Intraoperative Fentanyl and Sevoflurane Consumption With Esmolol and Sevoflurane

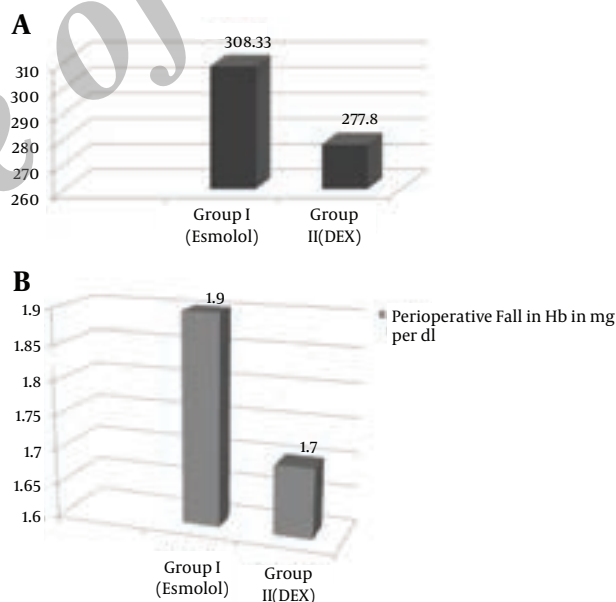


Figure 2. Intraoperative Blood Loss and Perioperative Fall in Haemoglobin With Esmolol™ and Dexmedetomidine

None of the patients in either group developed bradycardia less than 45 beats per minute that would necessitate atropine as pharmacological intervention. It was observed that hypotension in one patient in DEX group was treated with the loading dose under general anaesthesia, which required intervention with ephedrine and IV fluid bolus.

5. Discussion

Nowadays, it is of utmost importance to provide bleeding control by hypotensive anaesthesia during spine surgery both in terms of reducing intraoperative blood loss as well as providing satisfactory surgical field for the operating surgeon. The present study compared the effects of Esmolol and DEX as agents for hypotensive anaesthesia in lumbar spine surgeries.

Dexmedetomidine is a potent highly selective alpha-2 adrenergic receptor agonist. It has sedative, analgesic and anaesthetic sparing effects, and sympatholytic properties (8). The use of alpha-2 adrenergic agonist decreases the sympathetic tone that decreases HR, blood pressure and hemodynamic response to surgery (9). The analgesic and hypnotic effects of DEX and other alpha-2 agonists are due to its action at the locus coeruleus in the upper brain stem (10). Locus coeruleus has three important sets of efferent connections: 1) effects on cortical activity. Subthalamic relay nuclei, the thalamus and subsequent effects on cortical activity; 2) areas of vasomotor centres. Descending reticular formation with connections to pressor and depressor areas of vasomotor centres; 3) Reticulospinal tracts which inhibit pain transmission at the spinal level (Figure 3) (11).

Esmolol lowers arterial blood pressure through a decrease in cardiac output secondary to negative chronotropic and ionotropic effects of β -adrenergic antagonism. It provides a stable course of controlled hypotension and produces beneficial effects in the surgical field and in blood conservation (12, 13). Esmolol is used effectively to provide controlled hypotension intraoperatively in many studies (7, 14). Lim et al. used Esmolol to control hypotension in patients undergoing spinal surgery. They reported that Esmolol was an appropriate agent to control hypotension in acute normovolumic hemodilution to prevent blood loss in patients except those who do not have cardiovascular problems (15).

The present study showed better intraoperative HR and blood pressure stability while using DEX as a hypotensive agent compared to Esmolol. Ibraheim et al. used DEX and Esmolol to study effects on blood loss and hemodynamic changes and found that both were effective in reducing blood loss with DEX resulting in relatively prolonged recovery (14). Shams et al. used DEX and Esmolol with sevoflurane to control hypotension in functional endoscopic sinus surgery (FESS) and found both of them safe agents to control hypotension and effective to provide ideal surgical field during FESS with DEX having the advantage of inherent analgesic, sedative and anaesthetic sparing effects (7).

The estimated blood loss (EBL) in both groups in the study was much less than 300 millilitres. The EBL along

with the perioperative fall in haemoglobin value ensured minimal blood loss. Overall, two patients were excluded from the study and both were from the Esmolol group. Both of the patients developed unstable hemodynamics due to excessive intraoperative blood loss (greater than 1000 mL). None of the patients in either group developed bradycardia less than 45 beats per minute. Hypotension was observed in one patient in DEX group treated with the loading dose under general anaesthesia, which required intervention with ephedrine and IV fluid bolus. This condition was attributed to additive effect of volatile anaesthetic in general anaesthesia.

The methods aimed to decrease blood loss during spine surgery involve the controlled hypotension, local vasoconstrictors, use of drugs such as tranexamic acid, desmopressin, or use of local agents such as bone wax and haemostatic sponges (16).

The current study showed less intraoperative blood loss using DEX as hypotensive agent in lumbar spine decompression and fixation surgeries, which was consistent with the results of the studies that used DEX and demonstrated reduced blood loss in septoplasty, tympanoplasty and maxillofacial surgery; however, in these surgeries the importance of providing better surgical field is the primary aim (17, 18). In spine surgeries hypotensive anaesthesia has the roles to reduce the intraoperative blood loss and provide better surgical field. Durmus et al. used DEX 10 minute preoperatively in a dose of 1 μ g/kg and later 0.5 μ g/kg/hour in tympanoplasty and septoplasty. They assessed the bleeding score, and reported that DEX decreased bleeding. They did not observe hypertension, hypotension, bradycardia or tachycardia in any of the patients (19). Used different modalities such as hypotensive anaesthesia, cell salvage and hemodilution to reduce the possibility of transfusion, which was quite satisfactory (14). Mariappan et al. used alpha blockers to reduce intraoperative blood loss and found it quite effective. The results were similar to those of the current study (20).

The current study showed that the total intraoperative analgesic (fentanyl) use was significantly lower while using DEX ($P < 0.05$) compared to Esmolol. This can be due to sedative, analgesic and anaesthetic sparing effects, and sympatholytic properties of DEX (8). This analgesic sparing effect with reduction in total intraoperative fentanyl consumption was similar to those of the previous studies on DEX (18, 19). Ayoglu et al. found that while using DEX for intraoperative hypotensive anaesthesia for septoplasty and tympanoplasty, there was significant reduction in intraoperative fentanyl use (17).

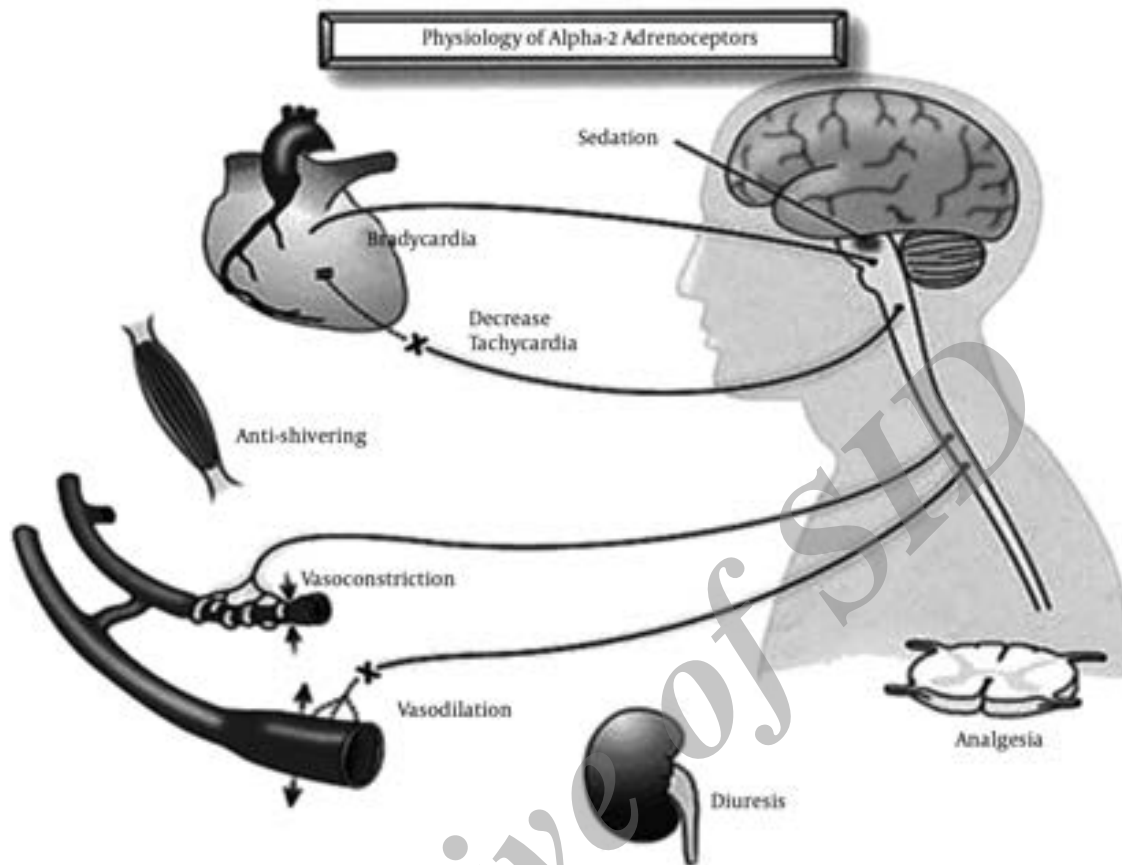


Figure 3. Physiology of Alfa-2-Agonists and Its Effects on Different Organ Systems

5.1. Conclusion

The results of the study showed that both DEX and Esmolol can be used as agents to control hypotension in patients undergoing lumbar spine decompression and fixation surgery. Although there was not much difference in intraoperative blood loss between DEX and Esmolol groups, DEX group, however, was associated with better intraoperative haemodynamic stability, reduced intraoperative analgesic and volatile anaesthetic requirements.

5.2. Limitations

The use of bispectral index monitoring during anaesthesia would have made it more practical to titrate analgesic and anaesthetic concentrations intraoperatively. It could not be used because of cost limitations.

Footnote

Authors' Contribution: Study concept and design: Ovais Nazir and Mushtaq Ahmad Wani; analysis and interpretation of data: Nadeem Ali; drafting of manuscript: Tarun sharma; critical revision of manuscript: Amit Khatuja and Rajesh Misra; statistical analysis: Mehreen Maqsood

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