

Hemodynamic effects of chest-knee position: comparison of perioperative propofol and sevoflurane anesthesia

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Background/aim: There are limited data in the literature investigating the effects of anesthetic agents on cardiac output used in the chest-knee position. The aim of this study is to compare the effects of inhalation and total intravenous anesthesia on cardiac output in patients undergoing lumbar discectomy in the chest-knee position.

Materials and methods: Forty patients undergoing discectomy in the chest-knee position were allocated to 2 groups. The first group (GrS, n = 20) received sevoflurane after thiopental induction, while the second group (GrP, n = 20) received propofol induction and infusion. Heart rate (HR), mean arterial pressure (MAP), peripheral oxygen saturation, cardiac output (CO), and cardiac index (CI) were recorded.

Results: Groups were comparable in terms of HR and MAP. The differences related to anesthetic technique and position were statistically significant within each group. Cardiac output and CI were similar between the groups. Cardiac output and CI of GrP were found to be decreased in the chest-knee position and significantly elevated in the supine position after surgery ($P < 0.05$). There were significant decreases in the mean CO and CI values recorded after the chest-knee position in GrP.

Conclusion: Sevoflurane is found to be superior when compared to propofol in patients undergoing surgery in the chest-knee position in terms of perioperative hemodynamic stability. Therefore, sevoflurane may be the anesthetic of choice, especially in patients operated on in the chest-knee position with suspected hemodynamic instability.

Key words: Chest-knee position, propofol, sevoflurane, cardiac output

1. Introduction

The vast majority of spine surgery related to lumbar disk hernia is performed in various prone positions under general anesthesia due to its surgical advantages. The hemodynamic effects of anesthetic agents are unavoidable in patients undergoing lumbar disk surgery under general anesthesia. Moreover, the positioning of these patients is another influential factor on hemodynamic parameters. As a frequently used prone position, the chest-knee position is known to have undesired effects like decreasing cardiac output (CO), preload, and mean arterial pressure (MAP) (1). However, there are limited data in the literature investigating the effects of different anesthetic regimens in the chest-knee position (2).

There are reports on the effects of anesthetic techniques and positions on hemodynamic parameters. When the effects of sevoflurane and propofol anesthesia on hemodynamic parameters in patients undergoing surgery for spondylolysis were compared, it was found that the

effects of these 2 techniques were comparable (3). Those authors only assessed noninvasive parameters, such as blood pressure, which may not be as sufficient as CO. CO is a good marker in order to demonstrate the functions of not only the cardiac but also the circulatory system. It can be measured in intubated patients noninvasively by partial rebreathing technique with a NICO monitor (4). The aim of this study is to evaluate the effects of inhalation anesthesia versus total intravenous anesthesia on CO by a noninvasive hemodynamic monitorization method in patients undergoing lumbar disk surgery in the chest-knee position.

2. Materials and methods

The study was approved by the Gazi University Ethics Committee. Forty American Society of Anesthesiologists (ASA) class I or II patients, aged between 19 and 60 years and undergoing discectomy in the chest-knee position, were included in the study after obtaining their written

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informed consent. They were then allocated to 2 groups. Patients with severe cardiovascular disease and respiratory disease, using beta blockers, and presenting with either more than 25% reduction of MAP or a heart rate (HR) of less than 50 beats/min during surgical procedure were excluded from the study. Patients were admitted to the operating room after a 6- to 8-h fasting period without premedication. They were then catheterized with an 18-G intravenous cannula and hydrated with 10 mL kg⁻¹ of normal saline for 1 h preoperatively. Immediately afterwards, noninvasive MAP, electrocardiogram, and peripheral oxygen saturation (SpO₂) were monitored (Odam Physiogard SM 786, 1995, France). Perioperative values were recorded before the intravenous (iv) administration of 1 µg kg⁻¹ fentanyl (Fentanyl Citrate, Abbott Laboratories, USA). The first group (GrS) received iv 5 mg kg⁻¹ thiopental (Pentothal Sodium, I.E. Ulagay-Menarini Group, Turkey) and the second group (GrP) received iv 2 mg kg⁻¹ propofol (Diprivan, Zeneca, UK) followed by 0.1 mg kg⁻¹ vecuronium (Norcuron, Organon Pharmaceuticals, USA) to facilitate endotracheal intubation in each group. Anesthesia was maintained by 2% sevoflurane (Sevorane, Abbott Laboratories) in GrS. Patients in GrP received iv propofol infusion with an initial rate of 10 mg kg⁻¹ h⁻¹ (IVAC 770 syringe pump, USA). Propofol infusion rate was reduced and titrated during the surgery. After the intubation, the patients were mechanically ventilated with a N₂O/O₂ (1:1) mixture (Taema, Alys, V301, 1991, France) and end tidal CO₂ (ETCO₂) levels were kept between 30 and 35 mmHg. In order to measure the CO, a NICO monitor (Novamatrix Medical Systems Inc., USA) was connected to the respiratory circuit. After placing the patients in the chest-knee position, the onset of surgery was allowed. At the end of surgery all anesthetic agents were discontinued after placing the patients in the supine position. In order to antagonize the neuromuscular block at the end of the surgery, all patients received iv 0.01 mg kg⁻¹ atropine with 0.04 mg kg⁻¹ neostigmine. The patients were taken to the recovery room after extubation and followed for 1 h in case of a problem. HR, MAP, and SpO₂ values were

measured before induction (T₀); at induction (T₁); 3 (T₂) and 6 min (T₃) after intubation; 3 (T₄) and 6 min (T₅) after positioning; 3 (T₆), 6 (T₇), 15 (T₈), 30 (T₉), 45 (T₁₀), and 60 min (T₁₁) after the surgical incision; just before supine positioning (T₁₂); and after supine positioning (T₁₃). CO and CI values were measured at 3 (T₂) and 6 min (T₃) after intubation; 3 (T₄) and 6 min (T₅) after positioning; 3 (T₆), 6 (T₇), 15 (T₈), 30 (T₉), 45 (T₁₀), and 60 min (T₁₁) after the surgical incision; just before supine positioning (T₁₂); and after supine positioning (T₁₃).

2.1. Statistical analysis

SPSS 10.0 for Windows (SPSS Inc., USA) was used for all statistical analyses. All values were expressed as mean ± standard deviation (SD) for the results found in each group. Age, body weight and height, duration of anesthesia, and surgery of the groups were compared with an independent Student's t-test, while ASA class and sex were compared by chi-square test. Mean arterial pressure, HR, CO, and cardiac index (CI) data of each group were compared using a one-way analysis of variance test after Bonferroni correction. P < 0.05 was considered as statistically significant.

3. Results

There were no statistically significant differences between the groups in terms of demographic data of the patients and the duration of anesthesia and surgery (Table).

As for HR evaluations, no statistically significant difference was found between the groups. There were significant decreases in T₄, T₅, T₇, T₉, and T₁₀ values when compared to T₂ values in GrS (P = 0.001 for T₂-T₄; P < 0.0001 for T₂-T₅, T₂-T₇, T₂-T₉, and T₂-T₁₀). Likewise T₇, T₈, T₉, and T₁₀ values were significantly decreased in GrP when compared to T₂ values (P < 0.0001 for T₂-T₇, T₂-T₈, T₂-T₉, and T₂-T₁₀). Moreover, a statistically significant decrease was found in T₁ when compared to T₀ in GrP (P = 0.027) (Figure 1).

Regarding MAP, no statistically significant difference was found between the groups. The evaluation within the groups revealed significant decreases in T₁, T₃, T₄, T₅, T₆, T₇, T₈, T₉, T₁₀, and T₁₁ values when compared to T₀ in GrS

Table. Demographic data, duration of anesthesia, and surgery [(mean ± SD (minimum-maximum))].

| | GrS (n = 20) | GrP (n = 20) |
|------------------------------|-------------------------|-------------------------|
| Sex (M/F) | 9/11 | 11/9 |
| Age (years) | 44.40 ± 10.78 (19-60) | 45.90 ± 8.96 (29-59) |
| BMI | 25.89 ± 2.56 (21-28) | 26.76 ± 2.48 (22-29) |
| Duration of anesthesia (min) | 104.70 ± 10.31 (85-120) | 105.50 ± 11.55 (82-122) |
| Duration of surgery (min) | 90.30 ± 10.82 (60-105) | 91.50 ± 11.66 (65-112) |

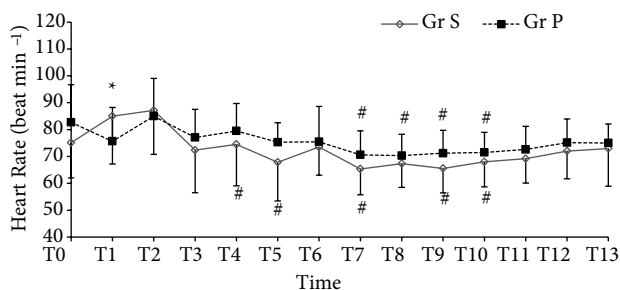


Figure 1. Heart rate values of the patients. *: compared with T₀ within the groups, #: compared with T₂ within the groups.

(P = 0.012 for T₀-T₁; P < 0.0001 for T₀-T₁, T₀-T₃, T₀-T₄, T₀-T₅, T₀-T₆, T₀-T₇, T₀-T₈, T₀-T₉, T₀-T₁₀, and T₀-T₁₁). There were also significant decreases in T₃, T₅, T₉, and T₁₀ when compared to T₂ in GrS (P < 0.0001 for T₂-T₃, T₂-T₅, and T₂-T₉; P = 0.001 for T₂-T₁₀). Mean MAP value at T₁₃ was significantly higher than that of the MAP value at T₅ in GrS (P = 0.001). Significant decreases were observed at T₅ when compared to T₂ in GrP (P < 0.0001). Additionally, significant decreases were found at T₁, T₃, T₄, T₅, T₆, T₇, T₈, T₉, and T₁₀ when compared to T₀ in GrP (P = 0.001 for T₀-T₃; P < 0.0001 for T₀-T₁, T₀-T₄, T₀-T₅, T₀-T₆, T₀-T₇, T₀-T₈, T₀-T₉, and T₀-T₁₀) (Figure 2).

Mean CO values did not show any significant difference between the groups. The comparison within the groups revealed a decline with respect to time in the mean CO values with the lowest value at T₁₁ in GrS. The cardiac output value of T₁₃, however, did not reach the values after intubation and remained higher than the values recorded at T₄ to T₁₁. However, these changes in GrS were not statistically significant. Similarly, in GrP the highest CO value, found at T₂, reduced with time. Although the difference between T₂ and T₃ was not statistically significant, the differences among T₅, T₆, T₇, T₈, T₉, T₁₀, T₁₁, T₁₂, and T₂ were statistically significant (P = 0.003 for T₂-T₅; P < 0.0001 for T₂-T₆, T₂-T₇, T₂-T₈, T₂-T₉, T₂-T₁₀,

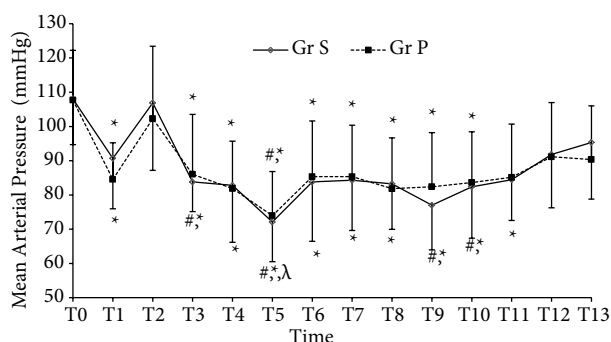


Figure 2. Mean arterial pressure values of the patients. *: compared with T₀ within the groups; #: compared with T₂ within the groups; λ: compared with T₁₃ within the groups.

T₂-T₁₁, and T₂-T₁₂). Mean CO values were elevated after placing the patients in supine position (P = 0.023 for T₁₃-T₁₂; P = 0.017 for T₁₃-T₁₀; P = 0.009 for T₁₃-T₉; P = 0.013 for T₁₃-T₈) just like in GrS (Figure 3).

No statistically significant difference was found in the mean CI values between the groups. There was a progressive decrease in the mean CI values with the lowest value at T₁₁ in GrS. The CI value at T₁₃ after placing the patients in the supine position did not reach the values of the postintubation period (T₂ and T₃), which was found to be higher than at T₅ and T₆ (P > 0.05). Similarly, the CI values of GrP decreased with time and the differences among T₅, T₆, T₇, T₈, T₉, T₁₀, T₁₁, and T₂ were found to be statistically significant (P = 0.007 for T₂-T₅; P < 0.0001 for T₂-T₅, T₂-T₆, T₂-T₇, T₂-T₈, T₂-T₉, T₂-T₁₀, and T₂-T₁₁). The CI value at T₁₃ after supine positioning was higher than those recorded at T₆, T₇, T₈, T₉, T₁₀, T₁₁, and T₁₂, but only the differences among T₉, T₁₀, and T₁₃ were statistically significant (P = 0.025 for T₁₃-T₁₀; P = 0.018 for T₁₃-T₉, (Figure 4).

4. Discussion

The most important finding of this study is provision of less hemodynamic alterations with sevoflurane anesthesia than total intravenous anesthesia with propofol in patients undergoing lumbar discectomy in the chest-knee position.

In the studies of Grounds et al. (5) and Muller et al. (6), thiopental has been demonstrated to cause tachycardia while propofol had no effect on HR. In our study, the quantitative HR increases in GrS after thiopental induction were not statistically significant. However, the significant decrease of mean HR detected in GrP during induction of anesthesia was not compatible with the previous data. This difference was considered to be due to the use of fentanyl during induction (7), since using propofol with opioid agents was reported to increase the frequency and the severity of bradycardia (8,9). Induction with thiopental or propofol is known to decrease MAP at a rate of 10%

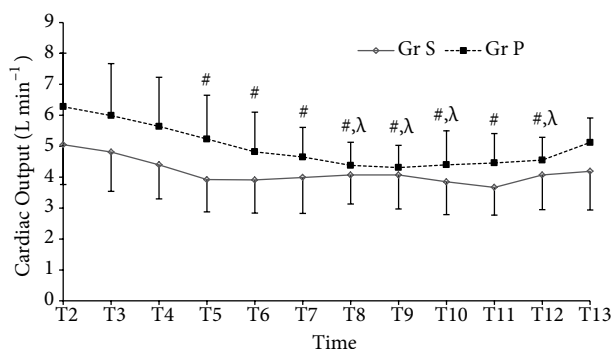


Figure 3. Cardiac output values of the patients. #: compared with T₂ within the groups, λ: compared with T₁₃ within the groups.

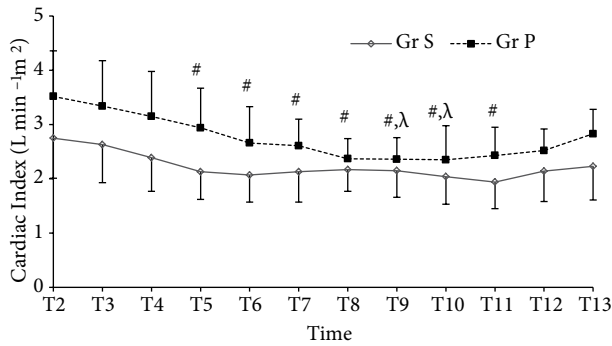


Figure 4. Cardiac index values of the patients. #: compared with T_2 within the groups, λ : compared with T_{13} within the groups.

and 25%–40%, respectively. Bilotta et al. (10) reported 20% versus 10% decrease in MAP when comparing fast (10 mg s^{-1}) and slow (2 mg s^{-1}) infusion rates of propofol. In order to prevent hypotension as a result of propofol induction, they recommended to avoid perioperative hypovolemia and use slow infusion rates. Similarly, bolus administration of thiopental is accepted as a cause of hypotension. Our results demonstrated a similar decrease in the rate of MAP by 16% and 21% after induction of thiopental and propofol, respectively. In the current study, although 2 different induction agents were used to compare the hemodynamic parameters, the alterations during the induction period in GrS could be related to thiopental, while perioperative changes in hemodynamic parameters might be related to sevoflurane because of the limited metabolic effect of the bolus dose of thiopental.

The effect of positioning on hemodynamic parameters in anesthetized patients has been also evaluated in the literature (2,11–13). No significant HR changes were demonstrated in anesthetized patients while moving the patient from the supine to the chest-knee position (13–15). The elevation of HR in GrS during the induction of anesthesia was thought to be a sort of stress response to intubation. The insignificant changes in mean HR values after positioning the patients in the chest-knee position in either group made us consider that the HR could be unrelated to the positioning of the patient.

Routine doses of sevoflurane have been known to decrease myocardial contractility and MAP in a dose-dependent manner (16). Gravel et al. (17) found sevoflurane superior to propofol for maintaining a stable MAP in patients undergoing cardiopulmonary bypass surgery. Watson and Shah (18) stated that either sevoflurane or propofol reduced MAP in a comparable manner and this effect was related to the decreased systemic vascular resistance due to the endothelium-mediated vasodilator effects of the drugs. In our study, MAP was found to be decreased in both groups after placing the patients in the chest-knee position. The MAP values in both groups

remained stable for a short time and then tended to decrease afterwards.

A rise in systemic and pulmonary vascular resistance with significant decreases in CI, CO, and stroke volume has been observed after placing the patients in the prone position (11). While evaluating the effects of the prone position, Yokoyama et al. (15) found that placing the patients in the chest-knee position, but not prone, following the supine position had significant effects on patients' CI values under halothane anesthesia. Likewise, Dharmavaram et al. (14) presented a significant decrease in CI in the chest-knee position. Sudheer et al. (2) evaluated the CI with NICO and presented a 25.9% decrease in CI after placing the patients in the prone position under propofol and total iv anesthesia. Isoflurane anesthesia caused a 12.9% decrease in CI in the study. Galimberti et al. (12) confirmed the decrease in CO with transesophageal echocardiography in patients placed in the chest-knee position under isoflurane with $\text{N}_2\text{O}/\text{O}_2$ anesthesia. We evaluated the cardiac functions with NICO and found a similar decrease in CI and CO in the chest-knee position and an increase in CI and CO after turning the patient back to the supine position at the end of surgery in either group.

In our study, the changes in CO presented a decreasing curve with time, including a peak value at T_2 during surgery in both groups. This curve is similar to MAP changes with time and the peak value at T_2 might be related to the stress response to intubation. The decreases in CO and CI in the prone position, which were comparable with the literature findings, were the result of the compression of the thoracic cage, peripheral vasodilatation due to the anesthetic agents used, and positioning of lower extremities below the heart level with sharp angles (1,19).

In a study evaluating the effects of hip joint angle on blood flow in the chest-knee position on healthy volunteers, Laakso et al. (1) demonstrated an increase in MAP after the chest-knee position. They represented these changes as a consequence of the participants being awake and made the assumption of possible hypotension in patients under general anesthesia due to effects of anesthetic agents like peripheral vasodilatation and myocardial depression (1).

The anesthetic agents sevoflurane and propofol are known to cause cardiovascular depression. Lepage et al. (20) and Rauby et al. (21) attributed this effect of propofol to the enhanced preload due to the increase in venous capacitance while Mullier et al. (6) attributed this effect to the negative inotropic effect of the drug. Sevoflurane, however, inhibits myocardial contractility, causes cardiovascular collapse at high doses, and preserves the CO at routine doses (17).

Gravel et al. (17) compared the effects of propofol and sevoflurane in patients undergoing coronary artery

surgery and found similar effects of both agents on CI, but they recommended sevoflurane as the hemodynamic parameters of the patients stayed more stable with this agent. In a similar study performed in patients undergoing laparoscopic cholecystectomy, Husedzinovic et al. (22) showed a statistically significant decrease in stroke volume by TEE under propofol anesthesia but a rather stable course with the use of sevoflurane. They also recommended sevoflurane in order to provide hemodynamic stability. Our study showed that the either agent used during surgery made the patients stable in a hemodynamic manner in terms of CI and CO. The balanced course in the CI during the maintenance of anesthesia, which was comparable with MAP, led us to consider either technique to be reasonable.

Several limitations of this study need to be mentioned. The results of the study would have been more accurate if the anesthesia level was standardized by using more objective parameters such as bispectral index values rather than clinical parameters. Additionally, target-controlled infusion would be a more suitable way to administer

propofol. The study needs power analysis for generalizing the results. In the propofol group, continuous infusion of an opioid would also provide better analgesia when compared to intermittent administration of fentanyl as used in the current study. Finally, using 2 different induction agents may be criticized. As was mentioned before, the alterations during induction period in GrS could be related to thiopental. However, the later changes in hemodynamic parameters are solely related to sevoflurane as the effect of thiopental diminishes due to the metabolism of the drug.

In conclusion, our data suggest that either the anesthetic agents or the chest-knee position has negative effects on hemodynamic status. Despite the undesired consequences on hemodynamics of these 2 agents, sevoflurane anesthesia provides more stable conditions in patients with ASA grade I or II undergoing surgery in the prone position when compared to propofol.

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