

Comparison between intravenous and thoracic epidural analgesia in single coronary artery bypass graft surgery

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Aim: To compare thoracic epidural analgesia with intravenous analgesia in patients who underwent coronary artery bypass grafting surgery.

Materials and methods: This retrospective study included 40 patients who had received elective single artery bypass surgery. After general anesthesia, one group was given patient-controlled thoracic epidural analgesia and the other group was given patient-controlled intravenous meperidine analgesia. Patient assessments were performed during the postoperative period and included the duration of hospital stay, pain and sedation scores, ambulation score, atrial fibrillation incidence, and organ morbidities.

Results: No differences were detected between the groups in the demographic or intraoperative data. However, a statistically significant difference was detected in favor of thoracic epidural analgesia for the duration of extubation and hospital stay, pain control, sedation grade, mobilization, and quality of recovery scores.

Conclusion: After single coronary artery surgery, thoracic epidural analgesia was more effective than intravenous analgesia; it also enabled earlier tracheal extubation and a shorter hospitalization period.

Key words: Coronary artery bypass grafting, analgesia, epidural, quality of recovery

Tekli koroner arter bypass greftleme cerrahisinde intravenöz ve torasik epidural analjezinin karşılaştırılması

Amaç: Koroner arter bypass cerrahisinde, torasik epidural analjezinin intravenöz analjezi ile karşılaştırılmasıdır.

Yöntem ve gereç: Bu retrospektif çalışmada elektif tekli bypass cerrahisi yapılan 40 hasta iki grup halinde incelendi. Genel anestezi sonrası bir gruba hasta kontrollü torasik epidural analjezi, diğer gruba ise hasta kontrollü intravenöz meperidin analjezisi uygulandı. Postoperatif dönemde yapılan değerlendirmede hastanede yatış süresi, ağrı ve sedasyon skorları, ambulasyon skoru, atrial fibrilasyon insidansı ve organ morbiditeleri incelendi.

Bulgular: İki grup arasında demografik ve intraoperatif veriler benzerdi. Ama, ekstübasyon zamanı, hastanede yatış süresi, ağrı kontrolü, sedasyon derecesi, mobilizasyon ve derlenme kalitesi skorları açısından torasik epidural analjezi lehine istatistiksel olarak anlamlı fark saptandı.

Sonuç: Tekli koroner arter cerrahisinden sonra analjezik açıdan torasik epidural analjezi intravenöz analjeziden daha etkin bulundu. Ayrıca torasik epidural analjezi daha erken trakeal ekstübasyona ve daha kısa süreli hospitalizasyona imkan verdi.

Anahtar sözcükler: Koroner arter bypass greftleme, analjezi, epidural, derlenme kalitesi

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Introduction

Numerous new surgical and anesthetic methods have been developed in order to decrease the cost, duration of hospital stay, and time off from work due to major surgeries like coronary artery bypass grafting (CABG). In recent years, studies found that the use of thoracic epidural anesthesia or analgesia (TEA) in CABG surgeries provided effective oxygen usage and delivery balance in the ischemic myocardium by selectively blocking cardiac sympathetic innervation (thoracic nerves 1-5). This reduced the surgical stress response, established hemodynamic stability, reduced the incidence of new supraventricular arrhythmias, and reduced myocardial ischemia (1-3). Thus, the use of TEA resulted in reduced infarct rates during surgery in patients with ischemic heart disease (4,5). In addition, TEA lowered the pain score, enabled earlier extubation, and reduced the incidence of complications, including respiratory system infections, acute renal failure, and acute confusion secondary to intravenous opioid usage (6,7). Therefore, patients were permitted earlier discharges (1-3,6,7). However, in some studies, TEA did not provide any advantages in myocardial infarct or mortality after CABG (8). Additionally, the choice of TEA may be hindered by potential complications in CABG patients, including epidural hematoma due to heparinization, hemodilution, and a decrease in coagulation factors.

In the present study, we studied patients who had undergone general anesthesia and single CABG surgery, and we compared the duration of hospital stay, pain and sedation scores, ambulation score, atrial fibrillation incidence, quality of recovery scores, and organ morbidities between patient-controlled thoracic epidural bupivacaine and intravenous meperidine analgesia (IVA).

Materials and methods

After obtaining approval from the ethics committee, we retrospectively evaluated the hospital records and files of patients who underwent ASA II-III elective on-pump single CABG surgery between February 2009 and April 2010. All of the patients received general anesthesia followed by patient-controlled analgesia. One group received TEA and the other

received IVA. Patients were included if they were under the age of 75 years, had received on-pump CABG with an internal mammary artery graft by median sternotomy, did not have any other cardiac abnormality or did not undergo revision operation, and had normal coagulation test values (e.g., partial thromboplastin time of <45 s, prothrombin time of <1.5, or platelet count of >80,000 cm^{-3}). Exclusion criteria were alcohol or other drug addiction, contraindications for epidural anesthesia, systemic or local infection, cervical and/or thoracic arthritis with a neurological deficit, or a history of thrombolytic or potent antithrombotic drug use within 1 week prior to the procedure. The use of aspirin was not considered a contraindication for epidural anesthesia. Twenty patients who met the inclusion criteria underwent TEA and another 20 matching controls were chosen among the patients in whom IVA was used as a routine application in our center. A routine perioperative β -blocker was used for all of the patients.

All of the patients received premedication of 10 mg of diazepam on the day before the operation and 0.05 mg kg^{-1} of intravenous midazolam on the day of the operation. All of the patients were monitored with electrocardiography, radial artery catheterization, central venous pressure measurement via the internal jugular vein, oximetry, urine output, capnography, the bispectral index (BIS), and nasopharyngeal and rectal temperature measurements.

Thoracic epidural catheterization was performed 2 h before surgery through the T_{4-5} or T_{5-6} interval with a median approach and drop-hang technique, with an 18-G Tuohy needle (Escopan + Docking System + Perifix Soft Tip, B. Braun Melsungen AG, Melsungen, Germany). The epidural catheter was tested with 3 mL of 1% lidocaine. For all of the patients, etomidate (0.2 mg kg^{-1}), vecuronium (0.1 mg kg^{-1}), and fentanyl (1 $\mu\text{g kg}^{-1}$) were used for the induction of anesthesia. Anesthesia was maintained with isoflurane at a minimum alveolar concentration of 1 (50% oxygen plus 50% air, and 0.5 $\mu\text{g kg}^{-1} \text{min}^{-1}$ remifentanyl infusion) after a bolus of 1 $\mu\text{g kg}^{-1}$. The depth of anesthesia was evaluated with the BIS. All of the hemodynamic parameters of the patients were recorded and intraoperative hypotension was treated with dopamine; hypertension was

treated with glyceryl trinitrate and additional drugs (adrenaline, amiodarone, etc.), and pacemaker use was recorded. A Dideco Evo oxygenator (Biodevices Inc., Quezon City, the Philippines) was used during the cardiopulmonary bypass after reaching the activated clotting time of >400 s with heparin at 300 U kg⁻¹. During the bypass, a prime solution consisting of 1000 mL of Isolyte-S (Eczacıbaşı Baxter, İstanbul, Turkey) and 500 mL of hydroxyethyl starch (Voluven; Fresenius Kabi, Bad Hamburg, Germany) was prepared, of which 700 mL was given retrogradely and 800 mL remained for administration in a nonpulsatile flow set of 2.41 L min⁻¹ m⁻². Mild hypothermia (32-34 °C) was achieved, and cold hyperkalemic cardioplegia was provided. The mean arterial blood pressure was maintained between 50 and 90 mmHg in all of the patients during the bypass. At the end of the bypass, heparin was antagonized by the administration of protamine sulfate at 1 mg 100 U⁻¹ of heparin. For patient-controlled TEA (Abbott Pain Management Provider; Abbott Laboratories, Chicago, IL, USA), a solution was prepared with 1.25 mg mL⁻¹ bupivacaine and 2 µg.mL⁻¹ fentanyl. The locking duration was set to 20 min, the infusion dose was 0.1 mL kg⁻¹ h⁻¹, the total dose lock range for 24 h was 180 mL, and the loading dose was 0.1 mL kg⁻¹. For patient-controlled IVA (Abbott Pain Management Provider; Abbott Laboratories), a solution was prepared with 5 mg mL⁻¹ meperidine. The locking duration was set to 10 min, the infusion dose was 0.1 mL kg⁻¹ h⁻¹, the total dose lock range for 24 h was 600 mg, and the loading dose was 0.1 mL kg⁻¹. The patients in both of the groups were taken to the intensive care unit after receiving the bolus doses. Patient-controlled analgesia was begun and continued for 3 days postoperatively. The patients were sedated with a propofol infusion (5 mg kg⁻¹ h⁻¹) in the intensive care unit before extubation. An oral dose of 500 mg of acetaminophen was given to the patients 3 times daily for 3 days postoperatively. Additional analgesic requirements were recorded. When required, patients were given diclofenac sodium at 75 mg intramuscularly as an additional analgesic.

The extubation time was recorded in the intensive care unit. Extubation criteria included (9): 1) response to verbal orders; 2) body temperature above 36.5 °C; 3) drainage from chest tube of less than 100

mL h⁻¹; 4) partial oxygen pressure over 70 mmHg or inspired oxygen fraction of >0.5; 5) partial arterial carbon dioxide pressure of less than 50 mmHg and respiration count of less than 20 min⁻¹ or pressure-assisted ventilation under 10 cm H₂O; and 6) hemodynamic stability.

Patients were also evaluated with the quality of recovery score (QoR-40) (8). Here, 5 parameters were assessed, including physical comfort (12 items), emotional status (9 items), physical independence (5 items), physiological support (7 items), and pain (7 items). QoR-40 scoring was performed preoperatively and during the first 3 postoperative days.

Mobilization of the patients was attempted on the first postoperative day. Mobilization scores were recorded during the first 3 postoperative days and were assessed (9) as follows: 0 = no movement; 1 = sitting on bed; 2 = standing up from bed; 3 = walking 25 m; 4 = walking 50 m; 5 = walking 75 m; 6 = walking over 100 m; 7 = walking over 100 m and climbing 1 flight of stairs; and 8 = walking over 100 m and climbing 2 flights of stairs. Those with 6 or more points were considered ambulatory.

The analgesic requirements of patients for the first 3 postoperative days were assessed with the visual analog scale (VAS), which ranged from 0 to 10 (10,11).

Sedation scoring was also conducted for the first 3 postoperative days. A 4-point sedation scale (12) was utilized as follows: 0 = complete awareness; 1 = mildly sedated (rarely asleep, but easily awakened); 2 = moderately sedated (usually asleep, but easily awakened); and 3 = seriously sedated (somnia, difficult to awaken).

We also assessed the total duration of the hospital stay. The criteria for discharge (9) included: 1) hemodynamic stability without arrhythmia; 2) easy mobility and ability to eat without help; 3) no fever and or signs of infection; 4) normal urination and defecation; 5) all meals taken orally; 6) pain controlled with/without oral analgesics; 7) ability to walk over 100 m and climb more than 2 flights of stairs; and 8) normal mental status.

All of the parameters used in the comparisons were extracted from the patients' hospital data, which were routinely recorded for all of the patients.

All of the data were analyzed with SPSS 11.5 (SPSS Company, Chicago, IL, USA). The t-test was used for comparing group means and the chi-square or Fisher's test was used to compare percentages. $P < 0.05$ was considered statistically significant.

Results

A total of 40 patients were eligible for inclusion in the study. Twenty patients received thoracic epidural bupivacaine analgesia (TEA group) and 20 received intravenous meperidine (IVA group). The 2 groups were not significantly different in demographics (Table 1) or in intraoperative parameters (Table 2). Moreover, there were no significant differences between the groups in postoperative parameters or side effects (Table 3).

When the patients were compared with regard to duration of intubation in the intensive care unit, a statistically significant difference was detected between the groups ($P = 0.001$). The TEA group was intubated for an average of 9.0 ± 2.0 h and the IVA group was intubated for an average of 12.4 ± 2.6 h. Furthermore, the duration of the hospital stay was

significantly shorter ($P = 0.008$) for the TEA group (6.5 ± 0.9 days) compared to the IVA group (7.6 ± 1.4 days) (Table 3).

The 2 groups were also significantly different in their postoperative mobilization scores and mobilization rates. The TEA group showed a more rapid recovery of mobility in the first 3 postoperative days ($P = 0.001$) (Figure 1).

Preoperatively, there were no differences between the groups ($P = 0.338$) in the QoR-40 scores. However, during the first 3 postoperative days, the TEA group had higher QoR-40 scores (day 1, $P = 0.001$; day 2, $P = 0.007$; and day 3, $P = 0.001$) (Figure 2).

Based on the VAS pain scores, patients in the TEA group experienced less pain during the first and second days ($P = 0.001$ for both days), and there was no significant difference between the groups on the third day ($P = 0.114$) (Figure 3).

Patients in the TEA group were significantly less sedated compared to patients in the IVA group during all 3 postoperative days based on sedation scoring (days 1 and 2, $P = 0.001$; day 3, $P = 0.036$) (Figure 4).

Table 1. Basic characteristics of the patients.

	IVA* group (n = 20)	TEA** group (n = 20)	P
Age (years)	61.3 ± 10.2	58.8 ± 9.7	0.442
Sex (male/female)	14/6	16/4	0.533
Weight (kg)	78.7 ± 13.5	81.4 ± 13.8	0.534
Height (cm)	166.0 ± 9.1	170.4 ± 7.5	0.106
Euro risk score	3.4 ± 2.7	2.8 ± 2.3	0.459
Left ventricular ejection fraction	59.4 ± 8.5	56.2 ± 12.5	0.360
Diabetes mellitus (%)	55	30	2.558
Hypertension (%)	65	40	2.506
Respiratory disorder (%)	0	5	1.000
Neurological disorder (%)	10	0	0.487
Smoking (%)	35	55	1.616
Alcohol use (%)	5	5	1.000

*Intravenous analgesia

**Thoracic epidural analgesia

Table 2. Intraoperative parameters.

	IVA* group (n = 20)	TEA** group (n = 20)	P
Bypass duration (min)	37.6 ± 7.1	33.8 ± 8.1	0.124
Duration of aortic clamping (min)	20.8 ± 4.4	19.0 ± 4.6	0.214
Total remifentanil dose (mg)	7.08 ± 1.2	7.38 ± 1.2	0.462
Erythrocyte suspension (U)	1.05 ± 1.1	0.95 ± 1.2	0.796
Dopamine infusion (%)	0	15	0.231
Adrenaline infusion (%)	10	10	1.000
Glyceryl trinitrate infusion (%)	0	5	1.000
Amiodarone infusion (%)	0	0	-
Pacemaker usage (%)	5	0	1.000

*Intravenous analgesia

**Thoracic epidural analgesia

Table 3. Postoperative parameters.

	IVA* group (n = 20)	TEA** group (n = 20)	P
Duration of intubated period (h)	12.4 ± 2.6	9.0 ± 2.0	0.001 [#]
Nausea (%)	25	5	0.182
Vomiting (%)	5	0	1.000
Pruritus (%)	5	0	1.000
Atrial fibrillation (%)	15	15	1.000
Ventricular extrasystole (%)	0	5	1.000
Serum creatinine elevation (%)	10	0	0.487
New onset neurological deficit (%)	10	0	0.487
Permanent pacemaker (%)	5	0	1.000
Duration of hospitalization (days)	7.6 ± 1.4	6.5 ± 0.9	0.008 [#]

*Intravenous analgesia

**Thoracic epidural analgesia

[#]P < 0.05

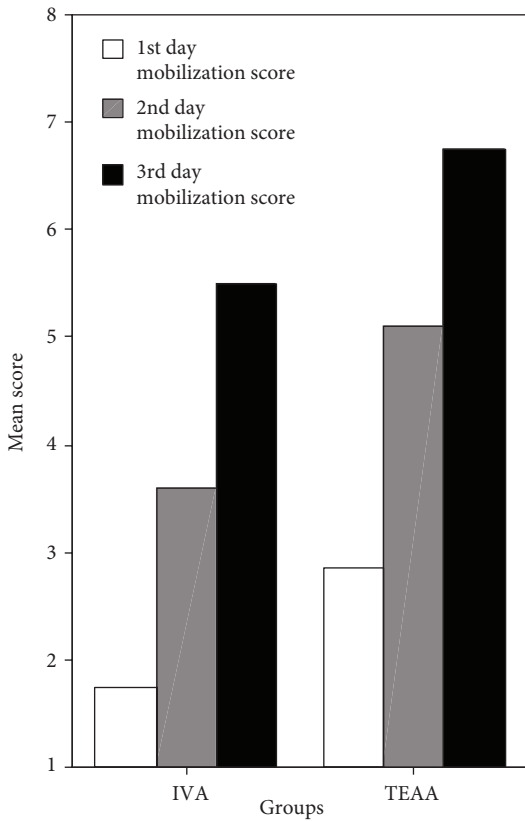


Figure 1. Mobilization scores during the first 3 postoperative days (IVA: intravenous analgesia, TEA: thoracic epidural analgesia).

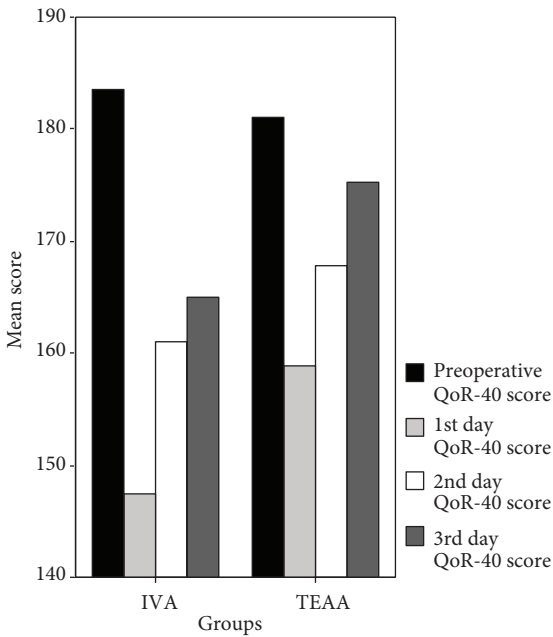


Figure 2. QoR-40 quality of recovery scoring preoperatively and during the first 3 postoperative days.

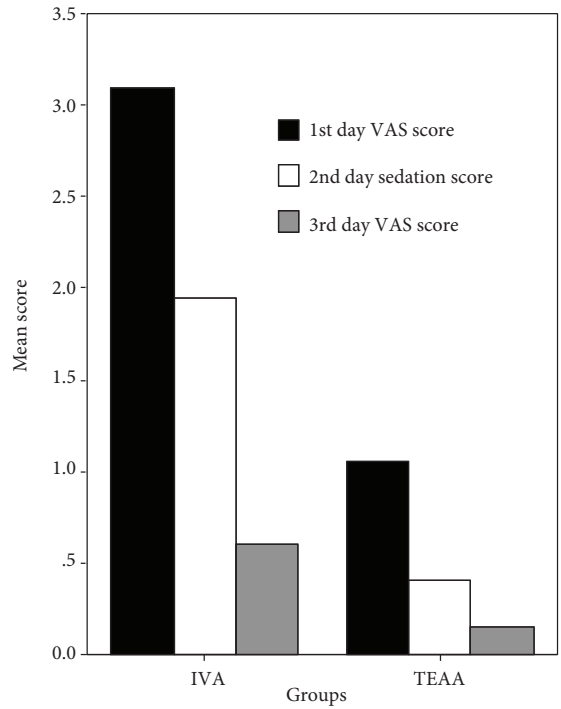


Figure 3. Pain scoring using VAS during the first 3 postoperative days.

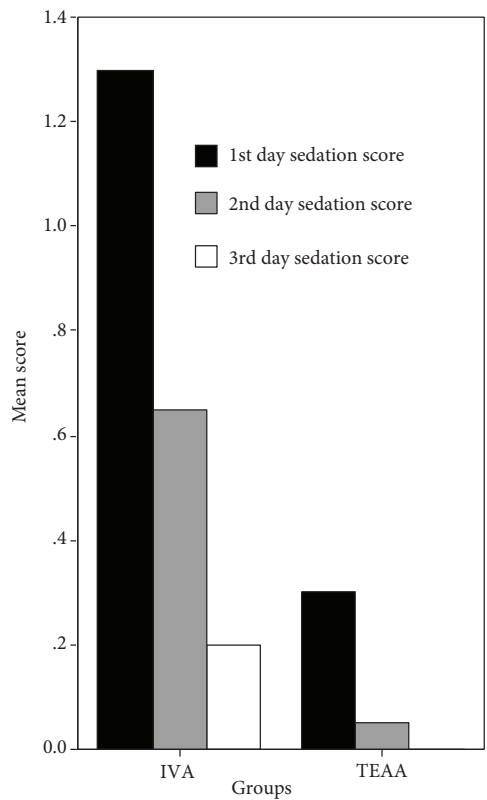


Figure 4. Sedation scoring during the first 3 postoperative days.

Discussion

In the past 20 years, TEA has been used more frequently in CABG surgeries due to its advantages in maintaining coronary blood flow, left ventricle function, release of angina, hemodynamic stability, stress hormone response, and respiratory function (7). In contrast, Priestley et al. showed that TEA did not shorten the duration of hospital stay, though it was associated with earlier tracheal extubation and better postoperative analgesia for patients who underwent coronary artery surgery (7). Hansdottir et al. also found that TEA did not shorten the duration of hospital stay (9). Those results contrasted with ours, possibly due to the anesthesia methods used and surgical procedures applied; both can have an effect on the duration of hospital stay. It is clear that many studies have applied different surgical protocols and different numbers of graft counts among the patients. Different surgical methods and any additional incision can also influence the duration of hospital stay. In the present study, we attempted to compare the effects of TEA and IVA in a more homogeneous group by including only patients who received a single on-pump CABG with an internal mammary graft; thus, we excluded patients who received off-pump CABG surgery or a saphenous vein graft and patients with any other cardiac abnormalities.

The duration of immobilization is a particularly crucial clinical parameter in the postoperative period. Immobilization raises the risks of thromboembolism and pulmonary complications. It also induces orthostatic intolerance and instability upon standing. In addition, it can cause losses in the quantity and function of muscle tissues. Immobilization in the supine position can delay wound healing by raising hypoxemia due to negative effects on the cerebral and cardiac systems (13,14). Thus, early, sufficient mobilization in the postoperative period is vital. In studies that used more effective multimodal analgesia methods, including epidural analgesia and opioids, patients had shorter immobilization durations (14). In our study, the TEA group had better mobilization scores than the IVA group during the first 3 postoperative days. This result was associated with early recovery, because the QoR-40 scores were significantly higher in the TEA group than in the IVA group during the first 3 postoperative days.

Various other studies have assessed postoperative analgesic effects of TEA on patients administered CABG. In a prospective, randomized study conducted by Royse et al., TEA was associated with lower pain scores compared to intravenous morphine, both at rest and during coughing, during the first 2 postoperative days (6). Priestly et al. also found that TEA provided better analgesia during resting and coughing compared to patient-controlled intravenous morphine, but that was limited to the first 24 h postoperatively (7). On the other hand, in a study conducted by Hansdottir et al., TEA was not more effective on postoperative pain control compared to patient-controlled intravenous morphine in a similar patient group (9). However, that study included patients who received multigraft and nonstandardized surgical procedures, which may have limited the efficacy of TEA. In our study, patients on TEA showed better analgesia during the first 48 h than patients on IVA, based on VAS assessments.

Nausea and vomiting are among the most frequent complaints that affect recovery in the postoperative period. Numerous factors can induce these symptoms; the most important, in connection with anesthesiology, are the method of anesthesia and the use of opioids. These symptoms can be prevented or improved by using nonopioid local anesthetics (14). In our study, there was no significant difference between the 2 groups in terms of nausea and vomiting; however, nausea and vomiting were encountered more frequently in the TEA group. This may be attributed to the low patient numbers in these groups; thus, we may not have had sufficient power to adequately assess the differences between the groups. Similar results were obtained in evaluations of new neurological deficits, including pruritus, agitation, and confusion.

Postoperative intubation durations are related to confusion and sedation levels, and they are closely associated with the method of anesthesia and analgesia. In some studies, among patients who received CABG, TEA provided a marked decrease in the incidence of acute confusion; this may have been secondary to a reduced need for opioids (3). A similar effect was noted for sedation (7). In the present study, we also detected markedly lower sedation scores in the TEA group compared to the IVA group during the

first 3 postoperative days; this contributed to earlier extubation and earlier discharge from the hospital.

Contradictory results have been reported in studies that examined perioperative TEA effects on the incidence of postoperative atrial fibrillation. In some studies, TEA administration during CABG reduced the atrial fibrillation incidence by 50%. However, other studies could not corroborate that effect (3,7). Jideus et al. compared pre- and postoperative sympathetic and parasympathetic activation, catecholamine discharge, and heart rates among patients who did or did not receive TEA. They demonstrated that TEA was associated with depressed sympathetic activity and markedly reduced epinephrine and norepinephrine levels. In that study, the lower atrial fibrillation rates observed in the TEA group were not associated with statistically significant differences in the outcome between the groups (15). In our study, no difference could be detected in the postoperative atrial fibrillation incidence between the groups. However, this could have been due to the fact that, in our study, both groups of patients received routine perioperative beta blockers for the prevention of atrial fibrillation.

One of the most important considerations regarding TEA application among patients undergoing cardiac surgery is that anticoagulation may lead to an increased risk of epidural hematoma, which may result in spinal cord injury. However, these complications are very rare (16,17). Only 1 out of 1528 patients who underwent a CABG experienced an epidural hematoma secondary to catheterization that resulted in spinal cord injury (16). Nevertheless, TEA must be applied by experienced personnel, and great attention must be given to the risks of heparinization, hemodilution, and reduced coagulation factors among patients undergoing cardiac surgery. In this study, no catheter-related complications occurred in the TEA group.

In conclusion, we found that in single coronary artery bypass surgery, patient-controlled TEA subsequent to general anesthesia was more beneficial than IVA. TEA was associated with improved postoperative pain control, earlier recovery and mobilization, earlier extubation, and a shorter hospital stay. We observed that this method can be safely used in patients undergoing CABG.

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