

# Awake versus combined general and epidural technique for off-pump coronary artery bypass grafting surgery: A retrospective comparative study

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Received 12 May 2013

Accepted 2 July 2013

The Egyptian Journal of Cardiothoracic Anesthesia 2013, 7:56–62

## Objectives

Our aim was to evaluate the effectiveness of thoracic epidural anesthesia and analgesia in off-pump coronary artery bypass grafting surgery. We examined its validity in patients under combined general/epidural anesthesia and in awake patients receiving epidural anesthesia as a sole anesthetic technique.

## Patients and methods

We evaluated 318 patients who underwent off-pump coronary artery bypass graft surgery between January 2008 and September 2009. Group A ( $n = 242$  patients, 76.2%) received combined general/epidural anesthesia and group B ( $n = 76$  patients, 23.8%) received only a thoracic epidural catheter as the sole anesthetic technique without general anesthesia or endotracheal intubation (awake). We compared the intraoperative hemodynamic and respiratory variables, postoperative pain (by Visual Analogue Scale), myocardial infarction, atrial fibrillation, intensive care, and hospital stay. We followed our patients for 1 year, clinically and angiographically, and compared the rate of graft occlusion.

## Results

There was no statistical difference in the intraoperative hemodynamic and respiratory variables (mean arterial pressure, heart rate, and partial pressure of arterial carbon dioxide) between the two groups, except for the partial pressure of arterial oxygen, which was higher in group A because of mechanical ventilation. There was no intraoperative mortality or postoperative myocardial infarctions in both groups. There was no statistical difference in the operative time between the two groups, but the patients in group A received a higher number of grafts than those in group B. There was no statistical difference in the postoperative pain scores; the mean pain score was  $1.425 \pm 0.42$  in group A and  $1.29 \pm 0.3$  in group B. The rate of atrial fibrillation was higher in group B (17%) than group A (7.02%) ( $P = 0.025$ ). The mean intensive care stay and the mean hospital stay were higher ( $2.77 \pm 0.9$  and  $7.314 \pm 2.8$  days) in group A than group B ( $1.269 \pm 0.4$  and  $3.743 \pm 1.2$  days) ( $P = 0.0038$  and  $0.0021$ , respectively). Follow-up through the first postoperative year with coronary angiography indicated vein graft occlusion in three patients of group A (1.23%) and one patient in group B (1.31%), but this was not statistically significant.

## Conclusion

We successfully performed off-bypass coronary revascularization surgery, including multivessel disease, under combined general/epidural anesthesia and in awake patients with thoracic epidural anesthesia as the sole anesthetic technique. Patients who are considered at high risk for general anesthesia and/or prolonged endotracheal intubation were good candidates for the awake technique as a valid alternative.

## Keywords:

awake, coronary artery bypass graft surgery, epidural, off pump

Egypt J Cardiothorac Anesth 7:56–62  
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1687-9090

## Introduction

Since the first animal study in 1954 that reported improved hemodynamics and decreased risk of supraventricular arrhythmias with thoracic epidural anesthesia [1], numerous clinical studies have been published over the past decade on the use of epidural techniques in cardiac surgery [2,3].

Experimental and clinical studies have suggested that central neuraxial blocks attenuate the response

to surgical stress, provide perioperative analgesia, and improve myocardial metabolism. This enables early extubation or operating without general anesthesia and ensures a smooth postoperative course [3].

With the increased interest in painless surgeries, the use of minimally invasive techniques, and fast tracking (for improved safety, complication prevention, and the reduction of costs), there is an increased interest in the use of high thoracic epidural anesthesia (HTEA)

in cardiac surgery [2,3]. Nevertheless, HTEA has not gained widespread utilization in cardiac surgery because of concerns of potential neuraxial hematoma, hypotension, and epidural infection [4].

With the increased complexity of cases presented for coronary artery bypass graft surgery (CABG) and the increased cases where patients are at a high risk for general anesthesia or mechanical ventilation, there is an urgent need for a safer technique for these patients. With the advancement in technology, pharmacology, and anesthesia, we are now able to safely perform awake off-pump coronary artery bypass (OPCAB) without general anesthesia or intubation for such cases [5,6].

The off-pump coronary artery bypass grafting (OPCABG) was first launched by Kolesov in the 1960s; now, it constitutes 30% of the CABG procedures performed worldwide [7–9].

Almost 15 years ago, Karagoz and colleagues had patients in their series who were not fit for endotracheal intubation and general anesthesia. They used the awake CABG strategy and proved its validity, and later, others started using it for single-vessel or minimally invasive CABG [10–13].

Awake CABG has been utilized for different surgical approaches including submammary, subxiphoid incision, and even in ministernotomy j-shaped incision [14,15]. Other authors used the awake technique for bilateral mammary and radial artery grafts; this means that all varieties of CABG were reported to be performed while the patient is awake [16,17].

Some authors advised adding a femoral nerve block to the HTEA in those patients; others combined the high thoracic epidural with the lumbar subarachnoid block in order to harvest the venous grafts [18,19].

Some surgeons reported opening the left pleura in awake patients undergoing CABG, and utilizing both mammary arteries with this technique. They reported that the sternum and the pleura could be opened safely without interrupting the diaphragm or the intercostal muscles to work properly and without disrupting the respiration [11].

After reviewing these reports on the use of epidural anesthesia in cardiac surgery and its utilization as a sole technique, we decided to carry out this study to evaluate the effectiveness and safety of this technique. In this study, we examine HTEA in patients under combined general/epidural anesthesia and in awake patients in OPCABG.

## Patients and methods

After institutional approval and obtaining informed consents, we examined 318 patients — in Saudi German Hospital al-Madinah al-Munawarah — who underwent isolated OPCABG from January 2008 to September 2009. We divided our patients into two groups: group A, in which all patients received combined general/epidural anesthesia ( $n = 242$  patients), and group B, in which all patients were awake under thoracic epidural anesthesia only ( $n = 76$  patients). In group B, 28 patients were considered at high risk for general anesthesia or intubation (21 patients had advanced pulmonary disease ( $FEV_{15} < 50\%$ ) and seven patients had advanced liver cirrhosis and persistently high liver enzymes).

All patients in group A underwent OPCABG. Seventy-three patients in group B underwent OPCABG and three patients had a single-vessel disease, LAD lesion, and were operated by minimally invasive direct coronary artery bypass surgery (MIDCAB).

Exclusion criteria: (awake group)

- (1) Uncooperative patient.
- (2) Small or diffusely diseased coronaries.
- (3) Pulmonary hypertension (moderate to severe).
- (4) Recent myocardial infarction.
- (5) Cardiomegaly.

Other comorbidities were not excluded including advanced liver disease, obesity, diabetes mellitus, renal disease, and advanced age.

Exclusion criteria for both groups: (for performing HTEA)

- (1) Activated partial thromboplastin time more than 45 s. (normal range = 25–30)
- (2) INR > 1.4.
- (3) Platelet count less than 80 000/mm (normal range = 150 000–400 000).
- (4) Administration of ticlodipine or platelet glycoprotein IIb/IIIa inhibitors 15 days before surgery.
- (5) Emergency surgery.
- (6) Low EF% less than 35%.
- (7) Spine anomalies.
- (8) Local or systemic infections.
- (9) Pulmonary hypertension (moderate to severe).
- (10) Preoperative insertion of an intra-aortic balloon pump.
- (11) Redo surgery.
- (12) Recent thrombolytic therapy.

Aspirin therapy below 160 mg/day and low-molecular-weight heparin therapy were not considered as contraindications for HTEA.

Exclusion criteria for the study: (for all groups)

- (1) Associated valve disease.
- (2) Associated ventricular aneurysms.

During the preoperative visit, the rationale and the procedure of operating awake using only thoracic epidural anesthesia was explained; six patients refused the procedure and were operated under combined general/epidural anesthesia, and we included these patients in group A. Three patients had failed a trial for epidural catheter insertion and were excluded from the study. All the patients included in this study agreed to epidural catheter insertion and the OPCAB procedure, and signed an informed written consent. Those operated awake signed a separate consent.

#### The anesthetic management

Patients received their usual cardiac medications early morning on the day of surgery. Premedication consisted of diazepam 5 mg orally, ranitidine 150 mg orally the night before surgery, on the morning of surgery, and morphine 0.1 mg/kg intramuscularly 2 h before being taken to the operating room. After arrival in the operating room, all patients were premedicated with intravenous midazolam 0.03–0.05 mg/kg.

A five-lead electrocardiography using continuous ST segment analysis, pulse oximetry, and noninvasive blood pressure monitoring were initiated. After performing modified Allen's test, an arterial catheter was inserted, under local anesthesia, into the left radial artery for monitoring of invasive blood pressure and arterial blood gases measurements.

In patients receiving general anesthesia, an epidural catheter (20-G; Portex) was inserted on the day of surgery (after checking an early morning coagulation profile) at the T4–5 interspace by using a midline approach and loss of resistance to air technique. Epidural catheters were inserted with patients in the sitting position using an 18-G needle with the bevel directed cephalad. The epidural catheter was advanced 4 cm into the epidural space and flushed with saline. A test dose of lidocaine 2% was administered, followed by a bolus of 4–8 ml of bupivacaine 0.25% + fentanyl 50  $\mu$ g 10–20 min before incision; then, an infusion of bupivacaine 0.125% + fentanyl 2  $\mu$ g/ml was started at 10 ml/h.

General anesthesia consisted of fentanyl 5–10  $\mu$ g/kg, propofol 1 mg/kg, and cisatracurium 0.15 mg/kg. After the trachea was intubated, a right internal jugular multilumen central venous catheter was inserted. Anesthesia was maintained using isoflurane 0.5% and its concentration was later adjusted as required on the basis of clinical conditions (heart

rate and blood pressure). Neuromuscular blockade was achieved using an infusion of cisatracurium at a rate of 3  $\mu$ g/kg/min.

Tracheal extubation was planned in the operating room. All patients were transferred after stabilization of hemodynamic and respiratory conditions to the ICU. Postoperative analgesia was provided by continuous TEA with bupivacaine 0.125% + fentanyl 2  $\mu$ g/ml at 6–14 ml/h supplemented with paracetamol 1 g intravenous infusion every 8 h.

In patients only receiving HTEA, the same steps were followed with the following differences: the bolus bupivacaine was changed to 0.5% concentration + 50  $\mu$ g fentanyl, whereas the infusion was changed to bupivacaine 0.25% + fentanyl 2  $\mu$ g/ml.

The central line was inserted under local anesthesia, a light sedation using ketamine 25 mg + midazolam 2 mg was administered before skin incision and sternotomy, and an oxygen face mask was started at a rate of 5 l/min. Endotracheal intubation equipment and a tracheostomy surgical tray were ready for any emergency.

For both groups, the Visual Analogue Pain Scale (VAPS) was recorded at 2, 4, 12, and 24 h after tracheal extubation.

The ICU hemodynamic monitoring and treatment protocols were the same for both groups.

#### The surgical technique

##### *Patients under combined general/epidural anesthesia (Group A)*

The patients were positioned supine on the operating table with a shoulder pillow, a urinary catheter was introduced, and a diathermy return pad was applied. The surgical field was sterilized with betadine 10% and the patients were covered by sterile surgical drapes.

A midline skin incision and full median sternotomy using the Stryker electric saw were used in all patients. The pericardium was first opened to assess the contractility of the heart and the pulmonary artery pressure manually, and then the left pleura was opened to harvest the left internal thoracic artery (LITA). The LITA was harvested as a pedicle and we did not use the skeletonized LITA technique. The LITA were harvested using low-energy coagulation mode spray diathermy with complete ligation of all branches. Heparin was administered at a dose of 2 mg/kg, aiming for an ACT value more than 200 s. The LITA were wrapped in a warm small gauze soaked with papaverine. The other grafts were then harvested (the radial artery

and the saphenous vein grafts). Gastroepiploic artery, RITA grafts, or Y and T grafts were not used.

A stitch was placed in the posterior pericardium 5 cm below the inferior left pulmonary vein and medial to the left phrenic nerve. This stitch was used to control the direction of the heart apex acting like the starfish cardiac stabilizer.

A large lap pad was placed under the heart and the heart was stabilized using a Medtronic octopus suction system to fix the territory of the target vessel. The epicardium was dissected over the coronary vessels and then the proximal part was controlled by a rubber stitch. The coronary vessel was opened with a size 11 blade and then the anastomosis was carried out using polypropylene 7/0 or 8/0. In all cases, we started with the LITA to the LAD, then the OMs then the Ds, and finally the RCA or the PDA. After completion of the distal anastomoses, the aorta was side clamped using the Satinsky C-clamp and the proximal anastomoses were performed using aortic punch number 4 for the radial and number 4.5 for the veins, polypropylene 6/0 for the veins, and 7/0 for the radials.

*The awake patients under HTEA only (Group B)*

The same steps and incision were used as in group A. We added a local anesthetic (lidocaine 2%) to the wound site, especially at the upper end, to ensure adequate pain control. The sternum was opened in the expiratory phase to minimize opening of the right pleura (the right pleura was unintentionally opened in three patients). The opening distance of the two sternal blades was reduced to decrease traction on the chest joints and allow smooth spontaneous breathing. The left pleura was opened in 32 patients (42%), but the respiration and the blood gases remained unaffected. We did not attempt to repair the pleura and we just placed a soaked sponge at the tear site.

*Both groups*

At the end of the procedure, the posterior pericardium was opened in 213 patients (88%) in group A and in 39 patients (51%) in group B (other patients had pleural adhesions). The chest tubes were fixed separately: one at the anterior mediastinum and the second at the left intercostal space. In 34 patients (49%) in whom we did not open the posterior pericardium, we placed the two tubes in the anterior mediastinum. Three patients in group B underwent MIDCAB surgery and had only left intercostal tubes. Routine figure of eight closure was performed using wire number 7 in all patients and low suction was applied to the drains.

Follow-up in the ICU and during the hospital stay with ECG and cardiac enzymes was performed when

needed. One hundred and thirteen patients (46%) in group A underwent coronary angiography within 1 year; three of them were symptomatic and the others were asymptomatic and electively volunteered to be checked. Thirty-two patients (42%) in group B underwent coronary angiography within 1 year; only one was symptomatic and the others were not.

All the patients were operated upon by the same surgical and anesthesia teams.

**Data processing and analysis**

Descriptive analysis (mean, SD, and student *t*-test) was carried out using the statistical package for social sciences (SPSS 17.0) including frequency distribution and cross-tabulation. Differences were considered significant at *P* value less than 0.05.

**Results**

There was no intraoperative mortality in either group. Also, there was no postoperative mortality after 1 year of follow-up in both groups.

The demographic data of both groups showed no statistical differences, except in the number of smokers; there were fewer smokers in group B (*P* = 0.062) (Tables 1–3 and Figs. 1–3).

The associated comorbid diseases (advanced liver and lung diseases) were higher in group B (*P* = 0.001 and 0.003, respectively). There were higher preoperative MIs in group A (*P* = 0.001).

The duration of operation and the time taken for the distal anastomosis were not significantly different between both groups (*P* = 0.7 and 0.8, respectively). There was a significant difference in the number of distal and proximal anastomoses, and the sequential

**Table 1 Preoperative data**

	Group A (n = 242)	Group B (n = 76)	<i>P</i> value
Age (mean ± SD) (years)	49.9 ± 7.1	47.965 ± 6.7	0.6
Sex (male%)	98	100	0.53
Hypertension [n (%)]	109 (45)	41 (53.9)	0.43
Diabetes [n (%)]	106 (43.8)	39 (51.3)	0.4
Dyslipidemia [n (%)]	97 (40)	34 (44.7)	0.7
Smoking [n (%)]	150 (61.9)	27 (35.5)	0.062
Weight (mean ± SD) (kg)	88.6 ± 12.6	87.975 ± 11.9	0.5
EF%	45.93	45.609	0.37
Advanced lung disease [n (%)]	0	21 (27.6)	0.003
Advanced liver disease [n (%)]	0	7 (9.2)	0.001
COPD [n (%)]	9 (3.7)	2 (2.63)	0.9
Recent MI [n (%)]	21 (8.67)	0	0.001

**Table 2 Operative data**

	Group A (n = 242)	Group B (n = 76)	P value
OR time (h)	3.15 ± 0.29	3.103 ± 0.29	0.7
Anesthesia time (min)	6.48	5.188	0.8
Number of distal grafts	4.06 ± 1.3	3.234 ± 1.1	0.037
Number of proximal grafts	2.371 ± 1	1.592 ± 0.7	0.041
Sequential [n (%)]	116 (50.2)	30 (34.48)	0.046
MAP (mmHg)	100.67 ± 12	95.612 ± 10	0.27
HR (beats/min)	75.43 ± 13	76.919 ± 15	0.31
PaO <sub>2</sub>	213.76 ± 73	96.241 ± 26	0.01
PaCO <sub>2</sub>	43.589 ± 9	47.362 ± 13	0.8

**Table 3 Postoperative data**

	Group A (n = 242)	Group B (n = 76)	P value
VAS	1.425 ± 0.42	1.290 ± 0.3	0.73
Postoperative AF [n (%)]	17 (7.02)	13 (17)	0.025
Postoperative MI [n (%)]	0	0	-
ICU stay (days)	2.772 ± 0.9	1.269 ± 0.4	0.0038
Hospital stay (days)	7.314 ± 3.1	3.743 ± 1.2	0.0021
Postoperative angiography (vein occlusion) [n (%)]	3 (1.23)	1 (1.31)	0.93
Postoperative ventilation (h)	0.421 ± 0.11	0	0.79

AF, atrial fibrillation.

grafts (more in group A than in group B) ( $P = 0.037$ ,  $0.041$ , and  $0.046$ , respectively).

The hemodynamics (mean arterial pressure and heart rate) were not different between both groups. The blood gases were stable in both groups, but the PaO<sub>2</sub> was higher in group A because of the mechanical ventilation ( $P = 0.01$ ).

The assessment of pain using the VAPS (Visual Analogue Pain Score) showed no statistically significant difference between both groups and the scores were low in both groups (1.4 and 1.29, with  $P = 0.73$ ).

The postoperative atrial fibrillation was higher in group B than in A ( $P = 0.25$ ). There were no reported cases of postoperative MI in both groups.

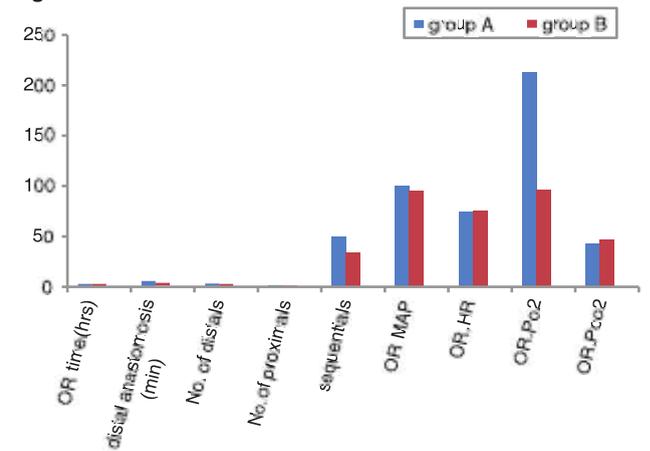
Comparison of the duration of mechanical ventilation did not show any significant difference between both groups ( $P = 0.79$ ). The ICU and hospital stay were longer in group A than B ( $P = 0.0038$  and  $0.0021$ , respectively).

There was no significant difference in the follow-up coronary angiography performed within 1 year of surgery between both groups ( $P = 0.93$ ).

## Discussion

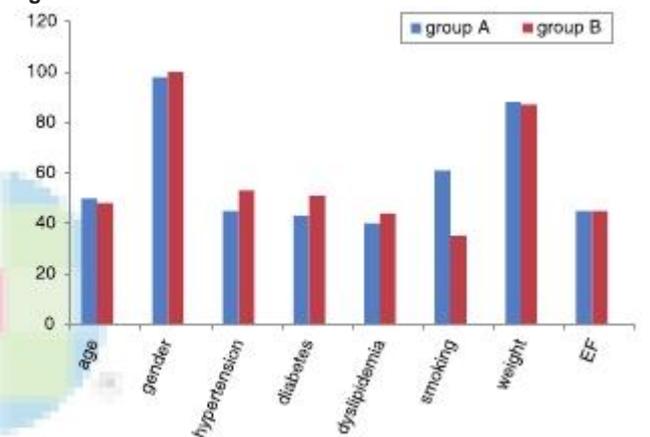
The use of the TEA has been reported in cardiac surgery, with a suggested benefit of better recovery,

**Figure 1**



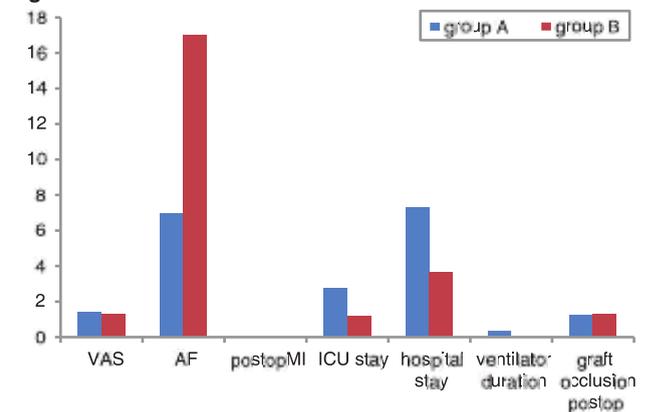
**Preoperative data.**

**Figure 2**



**Operative data.**

**Figure 3**



**Postoperative data. AF, atrial fibrillation.**

stable hemodynamics, fast tracking, less pain, fewer complications, and reduced expenses. Moreover, TEA may induce coronary vasodilatation, and other

arterial vasodilatation including the ITA, leading to better surgical results [11,20]. In addition, epidural analgesia may also lead to better graft flow and may induce a fibrinolytic action that may counteract the procoagulant state observed after beating heart surgery [18,21,22].

The development of OPCAB and MIDCAB has expanded the use of the HTEA. Although the awake patient technique was developed as a result of the increased utilization and familiarity of HTEA, it is still an immature technique with little literatures. Candidates for the awake technique should be psychologically prepared and should fully understand what to expect during surgery. In our study, most of the patients agreed to this technique and considered it a unique less invasive attractive option that facilitates fast recovery. A few others were apprehensive and refused it completely.

Unlike previous reports, our study examined only isolated CABG procedures without the use of CPB. In our opinion, this awake technique should be performed more commonly in off-pump surgeries as the patients selected for these surgeries had advanced liver or lung diseases (cannot withstand GA). The impact of CPB is a generalized effect on many body systems caused by the Kallikrein and complement system, and the resulting complications are not just the mechanical effect of the intubation, mechanical ventilation, or the pump tubing system [17,22].

One of the common problems that may be encountered is the difficulty in insertion of the catheter because of narrow spaces or an irritable, moving patient (about 3% of cases); fortunately, it yields a very minimal rate of complications (1 : 30 000) [11].

When performing the awake HTEA technique, it is important that the effect of the epidural block should remain below the level of C6. If a higher level is reached, paralysis of the diaphragm may occur and respiratory compromise may develop [11].

We added more local anesthetic (lidocaine 2%) to the wound site, especially at the upper end, to ensure adequate pain control. We also used the femoral nerve block technique that was described by other authors [6,11,19,23,24,25].

We attempted to avoid opening of the pleura during the sternotomy; thus, we used the saw during the expiration phase. This contrasts with the work of Karagoz, who performed the sternotomy during the

inspiration phase [10,11]. In our series, opening of the pleura did not affect the respiration as opposed to the patients in the other authors' work. In addition, in the previously mentioned study, the authors attempted to repair the open pleura with sutures; we just placed a saline-soaked gauze without any repairs and our patients did not develop any respiratory compromise [11].

The degree of sternal retraction in the awake patients should be less than that in anesthetized and mechanically ventilated patients. The reduced retraction lessens the tension on the chest wall joints and ligaments and allows for more efficient spontaneous breathing. However, the surgical field needs to be adequate and enough for surgical exposure. Cooperation and communication of the entire surgical team is vital for this technique to work.

There was a difference in the number of grafts between the two groups, which may be attributed to the advanced disease in almost 36% of the patients in group B and 4% with single-vessel disease, with a total of 40% of the patients subjected to less number of grafts. This was not because of an intended under revascularization as we grafted even the small targets and the distal ones.

In our study, there was a higher incidence of atrial fibrillation in the awake group. This might be because of the lack of posterior pericardiotomy and impaired drainage of the pericardium in that group.

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## Conclusion

It is safe to perform OPCABG by standard sternotomy for multivessel disease with or without general anesthesia using HTEA.

Our results showed that the rate of complications was similar in both groups, the awake and the combined general/epidural. The pain assessment scores were also almost the same in both groups, but the ICU stay and hospital stay were less in group B than A. We do not believe that this should be enough justification to perform all CABG surgeries using this awake technique. The awake technique should be reserved for patients at high risk for general anesthesia or endotracheal intubation.

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## Acknowledgements

### Conflicts of interest

There are no conflicts of interest.

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