Off-pump coronary artery grafting in awake patients with comorbidities using high thoracic epidural anesthesia

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Background
General anesthesia (GA) can be itself an obstacle to some patients with comorbidities to operate upon a mandatory cardiac surgery.
Patients and methods
Between January 2013 and May 2017 in the Cardiothoracic Surgery Department, Cairo University Hospitals; 31 patients of awake 'off-pump' (without cardiopulmonary bypass) coronary bypass surgery were performed by sternotomy, facilitated by thoracic epidural anesthesia. Analgesia was provided with thoracic epidural anesthesia at T2–3 interspace, using bupivacaine 0.5%, lidocaine 2%, and fentanyl 2 μg/ml until T1–8 dermatomal block was achieved, and then was maintained at 8–12 ml/h throughout the surgery. Success of awake off-pump coronary artery bypass grafting, without GA with appropriate surgical and medical conditions, was the target of the study.
Results
Thirty-one patients (range, 50–70 years) median, 61 years, weight (range, 70–109 kg) median, 78 kg, underwent surgery. Five (16%) patients needed conversion to GA: the left internal mammary artery was dissected, a saphenous vein graft was needed instead. Awake surgery was successful without complications in 68% of cases.
Conclusions
Off-pump coronary artery bypass grafting in awake old patients can be considered a safe and feasible technique with convenient surgical outcome especially in patients who cannot tolerate GA.

Keywords:
awake, comorbidities, off-pump heart surgery

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General anesthesia (GA) is the usual preferred anesthetic method for coronary artery bypass grafting (CABG). Many patients with other comorbidities are facing serious perioperative complications with GA and bypass. However, many other procedures (e.g. ultra-fast-track anesthesia) have evolved to reduce anesthetic or surgical complications [1,2]. Some studies have shown less perioperative problems as impaired consciousness and renal impairment by the use of off-pump coronary artery bypass grafting (OPCAB) [3].

Awake cardiac surgery was first described in 2000 by Karagoz *et al*. [1] by using thoracic epidural anesthesia (TEA) technique .

The high TEA was used as an adjunct to GA in patients with coronary artery disease, provided the patient was off anticoagulants [4–6].

Pain control by TEA avoids further deterioration of pulmonary functions and minimize postoperative pulmonary complications. Intraoperative hemodynamic stability may be improved through stress response modulation [1].

As TEA cannot persist for a long period into the postoperative period as all patients will receive prophylactic low molecular weight heparin 12 h by the end of surgery, provided that there is no postoperative bleeding. The OPCAB technique allows a reduction of heparin doses, possibly also reducing perioperative epidural hematoma risk [3,7,8].

Patients and methods

From January 2013 to May 2017 in the Cardiothoracic Surgery Department, Cairo University Hospitals and with informed written consent, 31 (28 men, three women) adult patients ranging age from 50 to 70 years old with ischemic heart disease for single-vessel CABG were prospectively enrolled in this study and underwent OPCAB without GA.

Patients' selection criteria included: patients with cerebrovascular impairment, either cerebral stroke

history of less than 3 months or preoperative carotid Doppler showing stenosis in bilateral carotid artery of more than 70%, who are at risk of cerebral ischemia due to reduced blood pressure during surgery; patients with chronic pulmonary disease [forced expiratory volume in the first second <49%; severe chronic obstructive pulmonary disease (COPD), mild to moderate interstitial lung fibrosis, scleroderma; restrictive lung disease,] and morbidly obese of more than BMI 40.

Exclusion criteria

Exclusion criteria were patients with ischemic heart disease who needs multivessel bypass graft, heart failure, severe pulmonary hypertension (systolic >50 mmHg), preoperative unstable hemodynamic or intra-aortic balloon, acute myocardial infarction (previous cardiac surgery), or patient refusal. Any psychological disease, coagulopathy, and end-stage hepatic disease can influence the patient selection.

Also, those allergic to drugs used and any local affection at the site of injection were excluded. The day before surgery epidural catheter was inserted. Our target was to reach somatosensory and motor block at the T1–T8 level. The patient was placed in a sitting position, and a 16-G flexible-tip catheter (Perifix Soft 505; B. Braun, Melsungen, Germany) was inserted under aseptic condition through a Tuohy needle at the T1–T2, T2–T3, or T3–T4 intercostal space by using the median approach and the loss of resistance or hanging drop technique. The catheter was directed cephalic and advanced 3–4 cm into the epidural space.

On the day of the surgery, the block level was tested by 5 ml of lidocaine (2%). An epidural solution was used for epidural anesthesia, consisting 20 ml of bupivacaine hydrochloride 0.5%, 20 ml 2% lidocaine 5 ml, and 0.25% fentanyl. In the operating theater, an initial bolus dose of 10 ml of epidural solution was used. Fifteen minutes later, the level of the block was assessed by temperature and pinprick discrimination. The block level was maintained by continuous infusion 8–12 ml/h by the solution composition described. If the mean blood pressure was decreased by more than 20% of its baseline, intravenous fluid was given, if the patient was not responding, a vasopressor was given and a peripheral venous line was inserted. A 0.07 mg/kg dose of midazolam was given as premedication.

All our patients were monitored by a five-channel ECG, direct arterial cannula insertion to blood pressure observation and blood gases sampling and central venous cannula insertion, pulse oximetry, urinary catheter, axillary temperature probe, and then oxygen face mask was applied.

A vertical skin incision was done after establishing the block level, midline sternotomy, hemostasis of the sternum, then opening the pericardium, and the left anterior descending (LAD) target vessel was explored. Then harvesting of the left internal mammary artery (LIMA) was done, if an accidental pleural opening happened the pleura is widely opened and the intercostal tube is inserted to avoid pneumothorax and subsequent pulmonary dysfunction. Anticoagulation was performed at 2–4 h after the epidural puncture, using nonfractionated heparin 150 IU/kg (activated coagulation time >250 s) appropriate for OPCAB. To stabilize the heart for OPCAB, we used a suction stabilizer over the epicardium at the planned site of anastomoses to LAD.

Occlusion of LAD with atraumatic vessel loops was established to prevent proximal and distal flow. Anastomoses of LIMA to LAD were created using a running 7–0 polypropylene suture. After completion of the anastomosis, mediastinal tubes 36 Fr were inserted and heparin reversed with protamine 1–1.3 mg/kg. Temporary pacing wire was inserted in the right ventricle, complete hemostasis achieved, then the sternum and skin were closed in the standard manner, and then patient was transferred to the ICU. With continuous epidural infusion: fentanyl 3 μg/ml at a rate of 6–10 ml/h for 8 h was administered. After catheter removal by 2 h low molecular weight heparin was started. The next day, the patients were transferred to the cardiac ward.

Parameters observed were the preoperative patient characteristics, operative details, and surgical outcome (follow-up for 1 year), and medical and surgical complications. We have monitored intraoperative PaO_2, $PaCO_2$, hemodynamic heart rate and blood pressure; and pain control was reported by visual analog scale. The inotropic needs, ICU and hospital stay. Early and delayed complications (surgical, medical, and anesthetic) were followed up to 1 year later.

Objective

Evaluation of patients with difficulty to tolerate GA to undergo awake OPCAB and the effect of this maneuver on surgical outcome and the medical condition.

Results

Thirty-one patients with IHD underwent OPCAB (range, 50–70 years) median, 61 years, weight (range, 70–109 kg) median, 78 kg.

Twenty-two patients with forced expiratory volume in the first second of less than 49% (COPD), seven of them were active smokers, four patients with mild to moderate interstitial lung fibrosis, one patient with scleroderma, three patients with cerebrovascular insufficiency, and one obese patient (BMI>40).

Midline sternotomy and harvesting of LIMA were successful in 28 (90%) patients, apart of five (12.8%) patients LIMA was dissected and we did not use it, saphenous vein conduit was used instead, so they were converted to GA. The mean operative time was 120 min; none of our patients needed inotropes. Four patients out of five patients who were converted to GA faced some difficulties on the weaning of ventilation. The four patients with COPD and interstitial lung fibrosis. Two of them were extubated after 4 days of surgery (relatively prolonged intubation). One was discharged after 11 days and the other after13 days (approximately two times the awake patients' hospital stay duration). The two other patients were tracheostomized approximately after 7 days of the surgery due to their respiratory distress, they were discharged from the hospital after 8 weeks with the recommendation of extensive physiotherapy at home.

Twenty-one (67.8.%) of the patients stayed in the ICU overnight and then were transferred to the cardiac ward; five (16.2%) patients who experienced atrial fibrillation stayed for average 4 days in the ICU and then average 8 days hospital stay and the other five (16.2%) were converted to GA patients, one of them stayed in the ICU for 3 days and then 5 days in the ward;two of them stayed in the ICU for an average of 12 (±3) days and then 20 (±5) days in the ward and the remaining two stayed in the ICU for 3 weeks and then 60 (±4) days in the ward. The mean hospital length of stay for the uncomplicated cases was 4–6 days (±5). There was no mortality or major morbidity. None of the early postoperative complications were detected such as respiratory tract complications, rebleeding, recent cerebral infarction, and heart failure; five of the patients experienced atrial fibrillation only, one patient of the five needed blood transfusion, none of the awake patients faced deterioration of his previous medical condition, none of the patients suffered from Horner syndrome or pneumothorax and no complications related to TEA.

Table 1 Patient characteristic and duration of operation number of patients and comorbidities

Number of patients	31
Age (year)	61 (50–70)
Weight (kg)	78 (70–109)
LVEF (%)	44 (35–55)
Duration of operation (min)	120 (100–145)
COPD (*n*)	22
Interstitial lung fibrosis (mild to moderate)	4
Scleroderma (*n*)	1
Obese	1
Cerebrovascular insufficiency	3

The data are presented by median and range. COPD, chronic obstructive pulmonary disease; LVEF, left ventricular ejection fraction.

Table 2 Hemodynamic and respiratory parameters

Total anesthetic epidural amount (ml)	28±7
PaO_2	91±5.2
$PaCO_2$	47±4.7
Systolic blood pressure (mmHg)	90±16
Diastolic blood pressure (mmHg)	55±8.8
Heart rate (min)	67±7.6
Visual pain analog scale	1.3±0.2

Data were presented by mean±SD. VAS: 0=no pain; 10=worst pain [9].

Each patient had a transthoracic echocardiographic evaluation at the first and second months, with no abnormality detected, other than the six patients who did not come back (they live far away); the rest of them who were followed up for 3 months to 1 year postoperatively were symptom free (Tables 1 and 2).

Discussion

In our study, the tolerance of complete epidural block (as the patients breathed only through the diaphragm), in spite of the block of intercostals muscles with absence of intraoperative respiratory parameters deterioration such as low PaO_2 or increased CO_2 level of more than 20% of the baseline. The preoperative high thoracic epidural promoted a superior pain control improving pulmonary functions and minimizing pulmonary complications especially related to intubation and ventilation due to its effective sensory block.

In present cases, we did not observe effective hemodynamic deterioration due to myocardial ischemia during coronary artery anastomoses and no arrhythmia. The heart rate was maintained at around 65. The systolic pressure was also maintained almost constantly at a mean of 70 mmHg in addition to the

depression on hemodynamics (heart rate and blood pressure) and stabilization of the cardiac function by blocking the sympathetic nerve cardiac branch.

It helped to provide a stress-free situation on patients during the surgery; so, there was heart rate and systemic blood pressure depression, this further depressed the double product. The cardiac oxygen consumption was reduced, and coronary artery and internal mammary artery become dilated. With the focus on vasodilating effect and inhibition of sympathetic nerve in TEA, this TEA is a convenient anesthesia for CABG. In addition to the hemodynamic stability promoted by TEA, the absence of the effect of bypass (e.g. inflammatory response, reduction of blood pressure) can protect the vital organs from any more harm [1,10].

Furthermore, ensuring consciousness was a good detector for cerebral perfusion and oxygenation which allows early detection on neurological, respiratory complications, and enabled proper treatment.

In patients with cerebrovascular disease before surgery, there was impairment of cerebral blood flow autoregulation mechanism, and cerebral infarction of the watershed type has been detected due to decreased blood pressure during bypass. This procedure is safer for cases with high-risk cerebral ischemia or respiratory insufficiency [10].

It is also for cases where GA was needed to be avoided or in cases of high possibility of complication. As well, epidural anesthesia solution exerts a sedative effect on patients, with no need for additional intravenous sedation or analgesia during the procedure, except for premedication of midazolam. As patients cooperation is important for monitoring diaphragmatic respiration and Horner syndrome development [6].

In awake cardiac surgery, several approaches to manipulate with the pneumothorax were described. One was to open the pleural space widely; another technique was to close the pleural space with or without insertion of thoracic drains [4,9]. However, cardiac surgeons noticed that the lung was retracted into the pleural space during spontaneous breathing, than during mechanical ventilation. This actually made mammary artery preparation easier [1,3,7] . Another relative limitation of epidural anesthesia is the failure to insert the epidural catheter in place in relatively old patients and patients with very tight or calcified intervertebral spaces. Aspirin is no more stopped before off-pump coronary artery surgery, irrespective of epidural anesthesia being used. The major problem of high TEA is the hematoma formation, which is estimated to be 1 in 150 000. This complication can be avoided by obeying such principles as a minimum time delay of 1 h between epidural puncture and heparinization. If blood tap occurred, surgery must be postponed by 1 day [11,12].

Maintenance of body temperature is an important aspect to minimize complications related to surgery such as shivering and coagulopathy. This was done in the routine way or temperature, heating blankets for lower body, and warm intravenous fluid to keep body temperature above 36° during surgery [2,5]. It goes with us, the study done by Noiseux and colleagues in Montreal Cardiac Surgery Department, Quebec, Canada in 2007, where 15 patients underwent awake CABG using TEA combined with femoral nerve block for saphenous vein harvesting to do multivessel disease CABG and their results were more or less similar to our study; among the 15 patients three (20%) of them were converted to GA, while the other 12 (80%) patients went smoothly without serious complications [4,8].

As well the study done by Watanabe and colleagues concluded awake OPCAB using TEA precludes the traumas associated with conventional GA. Although this technique requires advanced anesthetic technique and high-level surgical competence, this surgical procedure allows surgical treatment for high-risk patients with serious diseases in whom conventional CABG was not achievable, as well as allows early recovery and return to normal life early after surgery with marked improve in quality of life [13]. The study done by Karagoz *et al*. [14] to review their 3-year experience with 137 patients showed the feasibility and safety of this procedure that is less invasive than conventional CABG. The regional anesthesia which replaced the GA helped the patients to move earlier to the ICU with less incidence of complications. Definitely, there is the benefit of less hospital stay, and in turn, less cost, and better medical and surgical outcomes.

Our recommendations, to confirm the safety of this technique in comparison with conventional off-pump surgery many more patients need to be studied. The coming studies should focus on the effect of awake cardiac surgery on cognitive assessment and recovery. Owing to unresolved problems with on-pump awake cardiac surgery, especially temperature management and apnea at the beginning of extracorporeal circulation, OPCAB seems to be the main domain for this technique.

Conclusion

OPCAB in awake old patients confirms a safe and feasible technique with convenient surgical outcome especially in patients who cannot tolerate GA.

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Conflicts of interest

There are no conflicts of interest.

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