THORACIC EPIDURAL ANESTHESIA (TEA) has been in use for several decades in the armamentarium of anesthesiologists. It is used either as an adjunct to general anesthesia (GA) or to provide postoperative pain relief after cardiothoracic surgery. Its use during high-risk surgical procedures may reduce complications. Other benefits of TEA are improved analgesia, reduced ventilation time, better pulmonary function, reduced incidence of renal failure and myocardial infarction, coronary vasodilatation or cardio-protection, lowered stress response, better cardiac function, and reduced psychological morbidity. Additional benefits (which have limited evidence in the literature) are reduction in the incidence of atrial fibrillation, cost, and length of stay, both in an intensive care unit and a hospital. Fears about permanent neurologic deficits after use of TEA in cardiac surgical patients were expressed. There were two concerns: the concomitant use of antiplatelet medications in cardiac patients, and use of heparin intraoperatively. Two cases of permanent neurologic deficits were reported. Following this, several other authors expressed fear about the safety of epidural use in cardiac surgery and questioned its continued use. It is not surprising to find such a reaction from the community of cardiac anesthesiologists, considering the reluctance among surgeons and patients to accept anesthetic complications. Additionally, prevailing defensive medical practice might stop the use of TEA in cardiac surgical patients and, therefore, awake cardiac surgery (ACS).

The combination of off-pump coronary artery surgery and TEA appeared to lead inevitably towards awake surgery. It was thought that it would be impossible to carry out midline sternotomy and off-pump coronary artery surgery in non-intubated patients until the first report. Carrying out cardiac surgery under TEA in an awake non-intubated patient is called “ACS”. Ever since ACS was reported in the year 2000, several authors have reported their experiences. Potential benefits of ACS described by these authors were benefits in patients with pulmonary disease and airway difficulties, easy monitoring of cerebral function, benefits secondary to TEA, facilitation of fast-tracking, and cost reduction. Finally, the disadvantages that may be caused by administration of GA obviously are avoided.

The details of global experience of ACS may be found in Table 1. All these authors showed absence of permanent complications, neurologic or other. Despite this, many anesthesiologists continued to express apprehension about the safety of epidurals. Several “pro/con” debates about this topic were held in many congresses; there was no consensus, and the anesthesiologists continued to remain undecided as to whether or not to take up ACS as a viable option in existing practice. Once the feasibility of ACS was shown, even surgeries requiring cardiopulmonary bypass were conducted in awake patients. As an extension of this technique, awake transapical aortic valve implantation was reported. The dilemma of whether or not to routinely conduct ACS may have arisen due to the lack of overwhelming evidence supporting the use of TEA and ACS. Showing significant benefits of ACS may not be likely now or in the future, considering the decline in the rate of insertion of TEA due to extensive use of antiplatelet medications in cardiac surgical patients. It also is possible that, in an era of defensive medical practice, evidence may be required prior to the clinical use of a novel technique, which is the case for conducting ACS. Additionally, the medical fraternity expects anesthesia to be complication free, and complications due to anesthesia are unacceptable to patients and surgeons. The possibility of symptomatic epidural hematoma has prevented many from practicing TEA; the question of practicing ACS appears even more remote in their perspective. This review aims at touching upon these issues. It is common for novel techniques to go through such phases. William James (1842-1910), a famous American philosopher of the 19th century, said: “A new idea is first condemned as ridiculous and then dismissed as trivial, until finally, it becomes what everybody knows.” ACS is no exception to this quotation.

CURRENT STATE OF AWAKE SURGERY

ACS appeared to be a logical extension of minimally invasive surgery. ACS first was reported by Karagoz et al. These were termed “awake cardiac coronary artery bypass (ACAB) surgery” and “conscious off-pump coronary artery bypass graft (COPCAB) surgery.” Karagoz and colleagues suggested that conducting awake surgery might be one additional technique to minimize the “invasiveness” during surgery. Following this, several clinicians, including the author of this review, published their reports on various aspects of awake cardiac surgery. Initial reports included only off-pump coronary artery bypass surgeries while, subsequently, even cardiac surgeries requiring cardiopulmonary bypass were...
reported. \(^{30,31}\) Although the feasibility to perform surgery and lack of complications were acknowledged by all authors, apprehension about reproducibility of the technique arose in the minds of other anesthesiologists. This concern was discussed in many pro/con debates and invited commentaries and editorials. \(^{28,29,33,38}\) The debated issues were two-fold: first, the perceived absence of safety of epidurals in patients undergoing cardiac surgery and, second, the issues during ACS. These were not at all issues under conventional endotracheal general anesthesia. \(^{28}\) Because of lack of evidence, ACS continues to be a debated entity. Both issues are relevant to ACS. Epidural anesthesia is due to TEA rather than ACS. The other issues with ACS have improved over time. The improvement in surgical and patient outcome in clinicians’ experience is a testimony to that. The combined effect of widespread use of anticoagulants in patients with ischemic heart disease (thus precluding the use of TEA) and the fear of symptomatic epidural hematoma have prevented cardiac surgical teams from embracing this novel technique.

### INDICATIONS FOR ACS

The following were considered indications for conducting ACS: \(^{39}\) The target coronary artery more than 2 mm in size, absence of left ventricular dysfunction and valve regurgitation, and normal airway. Presence of pulmonary disease was not a contraindication for epidural use.

Contraindications to the use of epidural anesthesia automatically would eliminate the possibility of carrying out ACS. In addition, the following also may contraindicate ACS: Absence of patient consent, surgeon’s unwillingness, recent myocardial infarction, requirement of coronary artery endarterectomy, acute complications of myocardial infarction such as left ventricular free wall rupture/ventricular septal defect, and anticipated technically difficult surgery.

Benefits of performing ACS may result either from avoidance of endotracheal GA and/or from administration of TEA.

### Benefits Due to Avoidance of GA

Although GA has been used for a large number of patients daily without significant complications, documented hemodynamic responses to tracheal intubation, suction of the endotracheal tube, and extubation may lead to myocardial ischemia; this may pose a potential risk in patients with coronary artery disease. \(^{40,41}\) The avoidance of GA potentially may benefit the patient. \(^{42,43}\) However, never before was the avoidance of endotracheal intubation in cardiac surgery deemed necessary or feasible. \(^{17}\) In addition to these adverse effects of GA, endotracheal intubation has been shown to play an important role in causing pulmonary infection in intubated and mechanically ventilated patients. \(^{44}\) Endotracheal intubation has been shown to cause mucosal injury, reduced mucociliary function, bypassing upper airway defenses, and reduced effectiveness of cough. Avoiding any factors contributing to increased incidence of nosocomial pulmonary infection may benefit patients, especially those with cardiac implants. To many anesthesiologists, these benefits may not appear attractive enough to embark on the use of TEA in cardiac surgery.

A conscious patient can serve as the cerebral function monitor while undergoing ACS. \(^{25}\) Despite advances made in monitoring brain activity, no final word can be said about the safety and efficacy of commercially available cerebral function monitors. Monitoring cerebral function during ACS is useful. The author has reported patients getting irritable during phases of hypotension, which could be reversed by restoration of arterial pressure by placing the heart in a pericardial cradle. \(^{25}\) In yet another report, it was shown that patients undergoing ACS after carotid endarterectomy became unresponsive during clamping of the “culprit” internal carotid artery, which was reversed by declamping. \(^{28}\) Thus, a potentially serious problem of cerebrovascular ischemia was averted and surgery completed after insertion of an intravascular shunt. It is not known whether these potential advantages translate to clinical benefits; large-scale multicentric studies may be needed to arrive at conclusive...
evidence. Practitioners of ACS must remember that extreme hypotension or severe, sudden low cardiac output could produce a ‘sinking’ feeling for the patient. This has to be treated by timely correction of blood pressure and cardiac output; if that is not possible, the anesthesia must be converted quickly to GA so that the patient does not feel the ill effects of these events.

**Benefits Due to the Use of TEA**

A few benefits of TEA already have been described in the literature, and others are being researched. Various benefits such as hemodynamic stability,\(^2\) superior analgesia, reduced oxygen demand, optimal redistribution of coronary blood flow,\(^4\) attenuation of stress response,\(^2\) improved pulmonary function,\(^46,47\) early extubation,\(^48\) and decreased neurocognitive dysfunction\(^2\) have been reported.

**DISADVANTAGES OF ACS**

The disadvantages of ACS again can be divided into those possible due to avoidance of GA and due to use of TEA.

**Disadvantages Due to Avoidance of GA**

The disadvantages are described in brief here since the disadvantages have been published in detail by the author elsewhere.\(^39\)

*Unprotected Airway*

Cardiac surgeons and anesthesiologists commonly refrain from practicing ACS for fear of performing surgery in a patient with an unprotected airway. However, in the author’s opinion, since the cranial nerves are not blocked, upper airway reflexes and cough reflex are intact, and the patients are at no extra risk of aspiration. The fear of carrying out surgery in a spontaneously breathing patient is more theoretical.\(^17,33,60\)

*Inability to Perform Transesophageal Echocardiography (TEE)*

The problem of inability to perform TEE during cardiac surgery is real. The author performs epicardial echocardiography when valve function and wall motion abnormalities have to be assessed intraoperatively during ACS. It is encouraging that a report about carrying out TEE in unintubated patients may solve this problem. Guarracino and colleagues used noninvasive ventilation support to carry out TEE examinations in such individuals to avoid hemodynamic changes.\(^62\) If TEE is required during ACS, it may be performed as described by Guarracino et al.\(^62\) Use of TEE has not been given a high priority during the performance of off-pump coronary artery bypass grafting (OPCAB).

*Spontaneous Ventilation Causing Movement of the Heart and Great Vessels*

The surgical difficulty caused by the movement of the heart and great vessels may be minimized to a great extent by routine use of noninvasive pressure support ventilation through the face mask. It is the author’s observation that with recent modifications in the anesthetic technique, the mediastinal movement during spontaneous ventilation is greatly reduced, and, therefore, there is the need for noninvasive pressure support ventilation. Contrary to common belief, significant doses of sedation are not required to begin ventilatory support.

**Problems of Pneumothorax**

More and more clinicians are dispelling fears about pneumothorax in a spontaneously breathing patient.\(^17,22\) In the author’s experience, by making a few modifications such as using an oscillating saw instead of the conventional vertical saw to cut the sternum or carrying out the sternotomy during the inspiratory phase of spontaneous respiration, the incidence of pneumothorax could be decreased further. In addition, it seems to be a common misunderstanding that occurrence of pneumothorax is a sufficient enough reason to convert to GA.

**Diaphragmatic Paralysis**

Occurrence of diaphragmatic paralysis due to spillover block of the phrenic nerve is rare; it could be treated easily without adverse outcomes. Administering the local anesthetic agent as an infusion in the epidural space at the time of initiation of the epidural block seems to prevent this problem. The incidence in the author’s series of more than five hundred cases is 0.6%. The author has described the management of such an event elsewhere.\(^39\) While managing such events, significant doses of sedative medication are not required. As hypothesized earlier, a sensory block from the cervical 6 to thoracic 10 dermatome usually renders the patient drowsy, possibly because of suppression of the ascending reticular activating system.

*Gastric Distention*

Gastric distention may result due to continuous positive airway pressure ventilation in patients who are deeply sedated. The incidence at the author’s institution of gastric distention after ACS is 1.4%. It is common to see this complication in obese individuals undergoing ACS. During the early phase of the author’s experience, a nasogastric tube used to be inserted to prevent and/or treat gaseous distention of the stomach. With changes in the anesthetic technique towards better patient sedation and anxiolysis, the use of a nasogastric tube is not advocated because the incidence of positive pressure ventilation and gastric distention are now reduced.

**Inability to Communicate among Operating Room Personnel Freely**\(^39\)

It is suggested that the personnel in the operation room communicate softly with each other when the patient undergoes ACS. It is the author’s observation that a patient undergoing ACS usually is fast asleep even with minimal sedation. It has been hypothesized that this phenomenon could be due to reduced input to the ascending reticular activating system. It is also common to find patients who have received TEA extremely sensitive to the sedative medications. Considering these factors, interpersonnel communication may not be a problem. However, it is recommended that operating room personnel be sensitive to the issue that the patient might be awake and listening to conversations. An unpublished audit of patient satisfaction after conducted one to three weeks after ACS revealed good patient acceptance, pain relief, and overall comfort.
Possible Disadvantages of the Use of TEA

Requirement of Admission 1 Day Prior to Surgery

The author’s practice of performing epidural catheterization 1 day prior to surgery may be a point of debate; it is done at this institution because the patients for cardiac surgery are admitted to the hospital 1 day prior to surgery. In centers where patients are admitted only on the day of surgery, epidural catheters can be inserted 1 hour before the time of probable heparinization, and the technique of avoiding GA may be practiced. Admission of the patient 1 day prior to surgery is not required just to perform epidural catheterization.50

Temporary Neurologic Deficits

Although various authors have described temporary neurologic deficits during regional blocks,51–64 the incidence of peripheral nerve injuries associated with TEA appears to be very low. Two cases of temporary neurologic deficits have been reported55 but there were 37 unreported cases of temporary neurologic deficits in our series of 3,057 epidurals for cardiac surgery (incidence of 1.2%) over a period of 15 years. In a prospective study of 1,071 cases, no neurologic injuries were reported.56 Another investigation revealed that 10 out of 4,185 patients had peripheral nerve injuries,57 and other authors cited its incidence as 0% to 0.08%.58 Paresthesias and other neurologic complications following epidural catheterization occur even less frequently than dural puncture, with an estimated incidence of 0% to 0.08%.8 Paresthesias and other neurologic complications due to an epidural hematoma are not forthcoming about the possibility of complete restoration of neurologic function if this problem is diagnosed and treated early. The point that this complication remains reversible in its early stages has to be highlighted to improve the acceptance of an epidural in cardiac surgery so that the patient gets the benefits of TEA.

Permanent Neurologic Injury

Two symptomatic epidural hematomas in cardiac surgical patients12,13 were reported. The author believes that practitioners of TEA must adhere to the recommendations of Horlocker and colleagues to avoid this dreaded complication.65 In one of the cases,13 the epidural catheter was withdrawn prior to normalization of coagulation parameters. Had these authors followed the recommendation of the American Society of Regional Analgesia consensus guidelines, that complication could have been prevented. It is surprising that most authors who have commented on the topic of spinal cord compression due to an epidural hematoma are not forthcoming about the possibility of complete restoration of neurologic function if this problem is diagnosed and treated early. The point that this complication remains reversible in its early stages has to be highlighted to improve the acceptance of an epidural in cardiac surgery so that the patient gets the benefits of TEA.

Epidural Space Infection

Although epidural space infection is a potential complication of TEA in cardiac surgery, there appear to be no reports of it in the literature.

Bronchospasm

Theoretically, the sympathetic blockade in the thoracic level should induce bronchial constriction, which is not a common clinical observation.56 Clinicians from Brazil have reported increases in airway resistance following TEA.57 but no author observed any clinically significant bronchial constriction.

In an invited commentary, O’Connor suggested that “the issue of avoiding GA with endotracheal intubation is said to offer more risks with little advantage while exposing the patient to risks, which he would not otherwise be incurring (epidural hematoma, pneumothorax in a spontaneously breathing patient among others).”29 Therefore, the issue of coronary artery surgery without endotracheal GA remains controversial. The proponents of TEA suggest that epidural use should be encouraged. Royse summarized his editorial with, “If the sole purpose for TEA use is to substantially reduce postoperative morbidity and mortality, then there is insufficient evidence to recommend that practice. If the primary purpose, however, is to provide optimal pain relief and perhaps improve overall quality of care outcomes, then do not put down your Tuohy needles just yet.”64 Svircevic and colleagues failed to show any benefit when GA and TEA were compared; they questioned whether routine use of TEA should be encouraged considering the potential of TEA to cause epidural hematoma.65 Chaney pointed out that the data about the utility of neuraxial blocks in cardiac surgery are lacking.66 That being the situation, clinicians should refrain from using neuraxial blocks until morbidity and mortality benefits are shown. Hemmerling et al and67 Royse64 pointed out that the risk of hematoma is indeed low. Hemmerling et al67 recommended that an international registry for epidural hematomas in cardiac surgery should be established, a large multicentric clinical trial should be initiated, and a vigilant environment to avoid or treat the complications early should be made available.

HOW IS ACS PERFORMED?

The technique of performing ACS is described elsewhere.39 Here, the goal is to describe only the modifications in the anesthetic technique for ACS that have taken place in the recent past. One of those modifications was using ropivacaine instead of bupivacaine and administering it as an infusion over 20 minutes rather than a bolus administered by a hand-held syringe. This reduced the incidence of phrenic nerve paralysis and the side effects of the induction dose of an epidural such as hypotension and bradycardia.

Setting Up an Infusion of Ropivacaine at 5 mL/h

Ever since ropivacaine has been in use, requirement of continuous positive-pressure ventilation has become less frequent. In earlier cases, more than 500 µg of fentanyl in the intravenous and epidural routes were used.53 At times, patients would become very drowsy and needed continuous positive-pressure ventilation. Their cooperation during the surgery was lost. Over time, a very small dose of intravenous fentanyl (50 µg) is administered intravenously at the beginning of the block. The author now has found that this dose is adequate to prevent anxiety and keeps the patient “connected” with the anesthesiologists. The author hypothesized that epidural block might reduce the sensory and motor stimuli to the ascending reticular activating system and induce sleep. Dexmedetomidine has been made available in the author’s country recently; now, it is used routinely in all ACSs. Initial bolus of 1 µg/kg is administered over 30 minutes, and an infusion of 0.5 µg/kg/min
is prepared. This infusion is continued until the end of surgery. It has been observed that the patients are asleep. In the author’s opinion, this modification has made ACS more acceptable among all concerned. Postoperative epidural infusion containing ropivacaine is used now instead of a mixture of bupivacaine, fentanyl and midazolam. The patients are alert and ready to participate in physiotherapy activity more willingly now than earlier. Only aspirin is administered in the postoperative period in patients who have undergone coronary artery surgery. This practice has allowed the anesthesiologist to keep the epidural catheter in situ until patient discharge. Multimodal pain therapy, including intravenous paracetamol and transdermal diclofenac sodium patches, are used to provide pain relief rather than depending on the epidural route alone.

Anesthetic and Surgical Issues Influencing Patient Safety and Comfort

Anesthetic and surgical issues during awake cardiac surgery are peculiar to the technique, and the clinicians need to understand them prior to attempting this novel technique. Awake cardiac surgery largely is surgicentric. Several areas of awake cardiac surgery markedly differ from conventional surgery under general endotracheal anesthesia. Both the anesthesiologists and the surgeon should look out for these problems. Performing successful ACS depends on excellent teamwork of all personnel in the operating room. The surgical and anesthetic issues that are required to be understood prior to practicing ACS are issues concerning safe harvesting of the internal mammary artery and other conduits. These issues have been covered in detail by the author’s review on anesthetic techniques in ACS. Management of pneumothorax, hypoxia, arrhythmias requiring cardioversion or defibrillation, phrenic nerve block, and hemodynamic issues in an awake patient have to be well understood prior to conducting ACS.

Conversion to GA

This consequence is always kept in mind to prevent, or avoid or treat complications during ACS, which may be required when the block wears off and excessive patient movement prevents harvesting of the internal mammary artery. Deteriorating hemodynamic parameters, uncontrolled arrhythmias, cardiac arrest, hyperventilation, coughing, or patient irritability also may require either ventilator support or conversion to GA. Failure to improve oxygenation in patients undergoing ACS under cardiopulmonary bypass is yet another indication for conversion to GA. Other aspects of conversion to GA have been described elsewhere.

FUTURE OF ACS

It depends on two key factors; first, the opportunity to use an epidural in cardiac surgical patients and, second, practicing ACS. With the prevailing use of antiplatelet medications, it is not known how frequently TEA could be used in cardiac surgical patients in the future. Horlocker and colleagues have recommended avoidance of epidurals in patients receiving antiplatelet medication. They have opined that epidural use may be practiced in them only after discontinuing these medications for at least 14 days for ticlopidine and 7 days for clopidogrel. As per these recommendations of the Consensus Conference II of the American Society of Regional Anesthesia, most of the present-day cardiac patients may have been excluded from receiving epidurals. The other issue about inserting epidural catheters in these patients is that there is no wholly accepted test, including the bleeding time, that will guide antiplatelet therapy. The medical fraternity should renew analysis to learn if the current use of antiplatelet medication could be more rational. Benefits of antiplatelet medication in patients with ischemic heart disease is beyond question, but research should be directed at developing antiplatelet agents that have a shorter duration of action, predictable termination of action after cessation, and reversal by yet another agent. When such an agent is made available, many of the adverse effects of antiplatelet agents would be avoidable, and administering TEA also would become a more frequent possibility.

A task force should be organized at the international level to assess the factors leading to symptomatic epidural hematoma. Unless more epidurals are inserted in cardiac surgical patients, the real incidence of epidural-related complications will be unknown, and anesthesiologists will remain critical about using them. Carrying out ACS might be particularly beneficial in patients with myasthenia gravis, airway abnormalities, chronic obstructive pulmonary disease, and dialysis-dependent renal failure. It is the author’s observation that the cardiothoracic surgical team should be able to perform ACS in reasonably low-risk patients so that they easily could repeat it if a high-risk patient untreated or requiring GA is scheduled for surgery. The current literature about the practice of ACS is sufficiently strong to recommend a randomized clinical trial to examine the effect of the ACS approach on quality of recovery, including effect on cognition, stress, and outcome. It is true that ACS has not attracted attention from clinicians in developed countries, evidenced by lack of publications from the United States and Europe; defensive medical practice there coupled with absence of evidence in support of use of epidural and ACS may have caused it. A combination of occurrence of symptomatic epidural hematoma during epidural use and lack of evidence showing benefits of TEA over GA have made the practice of administering epidurals difficult in cardiac surgical patients. Needless to say, the future of ACS under such circumstances would be bleak. Unless shorter-acting antiplatelet medications that could be titrated and whose action could be assessed arrive on the market, carrying out any neuraxial block and techniques dependent on their use would “go the way of the dinosaur.”

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