

Benefits and Risks of Epidural Analgesia in Cardiac Surgery

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INADEQUATE ANALGESIA after cardiac surgery may lead to increased morbidity due to adverse hemodynamic, immunologic, metabolic, and hemostatic alterations.^{1,2} Adequate perioperative analgesia may improve patients' outcomes in the postoperative period,³ during which many modalities for optimal pain relief can be used, such as intravenous opioids, nerve blocks, local anesthetic infiltration, nonsteroidal anti-inflammatory drugs (NSAIDs), and neuraxial blocks.

Neuraxial block, such as thoracic epidural analgesia (TEA), first was described in cardiac surgery in 1954.⁴ In 1976, it was described the first preoperative insertion of thoracic epidural catheters in patients undergoing cardiac surgery.⁵ Since then, this technique has been used to achieve a variety of goals, varying from adequate analgesia to effective control of hypertension and stress response attenuation.⁶⁻¹⁴ In this review, the physiologic effect of TEA during cardiac surgery, based on the literature, is discussed, including its indications, contraindications, and complications, particularly in heparinized patients or patients on antiplatelet medications. The risk-benefit ratio in relation to specific comorbidities such as morbid obesity, chronic obstructive pulmonary disease (COPD), and advanced age also are discussed.

PHYSIOLOGY OF THE CORONARY CIRCULATION

Beyond the autoregulatory range, coronary blood flow is related directly to coronary perfusion pressure and inversely related to coronary vascular resistance. Neural effects on cardiac performance and rhythm are mediated via α - and β -adrenergic receptors.¹⁵ Endothelium also plays an important role in the tone of coronary arteries, and endothelial dysfunction will have deleterious effect on the mediation of sympathetic activity. Animal models have shown an intense poststenotic coronary vasoconstrictive mechanism mediated by cardiac sympathetic nerve activation that attenuates local metabolic coronary vasodilation in response to myocardial ischemia.^{16,17}

EFFECT OF EPIDURAL ON THE CORONARY CIRCULATION

High TEA has the potential of blocking cardiac afferent and efferent fibers that originate from the first to fifth thoracic level (T1-5). The perception of cardiac pain is mediated by sympathetic afferent nerves, and stimulation of efferent nerves leads to increase of inotropic action, cardiac output, and systemic vascular resistance. Local anesthetic administered through the epidural route targeted to T1-T5 segments produces motor or sensory blockade and blockade of cardiac sympathetic fibers. The effect is proportional to the concentration and volume of the agent used. The higher the level of TEA, the

greater the chance of hemodynamic instability due to vasodilatation, hypotension, and motor blockade; therefore, TEA is preferred over high TEA. Moreover, TEA increases the diameter of stenotic coronary arteries without any dilatation of coronary arterioles, thus maintaining myocardial oxygen balance, and may improve left ventricular function.^{18,19} TEA also helps in preventing cardio-cardiac reflex and increases endocardial-to-epicardial blood flow ratio with decrease in poststenotic coronary vasoconstriction.²⁰ Moreover, TEA improved recovery from stunned myocardium and decreased the size of the infarcted zone in experimental animals.²¹ Jakobsen et al²² studied the use of TEA in elderly patients and found better cardiac indices represented by end-diastolic volume index, stroke volume index, cardiac index, central venous pressure, and central venous oxygen saturation without increase in heart rate. Pro-BNP levels were significantly lower in the TEA group;²³ however, in part two of the study, TEA neither reduced the time in the intensive care unit (ICU) nor led to improvement in the quality of recovery in ICU.²⁴

EFFECT ON PULMONARY FUNCTION

Pulmonary dysfunction due to impaired ventilation is common after cardiac surgery, as reflected by postoperative hypoxemia and reduced forced vital capacity (FVC). Postoperative pain and impairment of diaphragmatic function are important determinants of pulmonary dysfunction.²⁵ Diaphragmatic dysfunction occurs with stimulation of afferent nerves in the chest wall, viscera, and diaphragm, leading to an inhibition of phrenic nerve drive. Thus, attenuation of pain by TEA may lead to prevention of episodes of hypoxemia and ventilatory dysfunction and also to improvement in the diaphragmatic function. Animal studies found that TEA may have a detrimental effect on the ventilatory parameters by denervation of the rib cage.²⁶ This, in turn, may lead to alterations in the lung volume, such as decrease in tidal volume and minute ventilation as the level of the block increases, and decrease in functional residual capacity, along with reduction in intrathoracic blood volume. This effect is directly proportional to

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1053-0770/2601-0001\$36.00/0

<http://dx.doi.org/10.1053/j.jvca.2013.07.016>

Keywords: epidural, analgesia, anesthesia, cardiac surgery, postoperative pain management

the level of block and concentration of the local anesthetic agent. In the authors' experience, this effect is not seen clinically with the concentrations and volumes of local anesthetics used in TEA.

A study in elderly patients found better preservation of postoperative pulmonary functions after cardiac surgery in addition to better analgesia and early extubation. They also found better FVC, FEV₁ (forced expiratory volume in 1 second), and oxygenation in the TEA group.²⁷ The authors also studied the use of TEA in COPD patients undergoing elective off-pump coronary artery bypass grafting surgery (OPCAB) and found it to be a good adjuvant to general anesthesia (GA) with regard to early extubation, shorter oxygen withdrawal time, faster recovery of pulmonary function (improved FVC and FEV₁), and better analgesia (ie, lower visual analog score [VAS] at rest and on coughing). Moreover, there was better compliance to chest physiotherapy and better atelectasis score as assessed by Richter's radiologic score.²⁸ Similar results along with shorter ICU stays were observed by this group in obese patients (body mass index >30 kg/m²) undergoing OPCAB who were administered TEA.²⁹ Overall, TEA decreases atelectasis and subsequent pneumonia, thereby leading to decrease in pulmonary complications.

EFFECT ON COAGULATION SYSTEM

Epidural analgesia has a significant effect on the coagulation status. Hypercoagulability is common after major surgery because of increased levels of fibrinogen, platelet activity, and plasminogen activator inhibitor-1 (PAI-1).³⁰ The Perioperative Randomized Anesthesia Trial (PIRAT) study group found a significantly reduced rate of lower extremity graft occlusion in patients who received epidural versus GA. PAI-1 activity was higher in the GA group 24 hours after surgery.³¹

POSTOPERATIVE ANALGESIA

TEA has been used primarily to provide reliable postoperative analgesia. Local anesthetic and/or opioids can be administered through the epidural route to achieve optimal analgesia. There are various studies that have validated its role in cardiac surgery as an analgesic, thereby facilitating early extubation.³²⁻³⁴ There is less requirement of intravenous rescue analgesia in patients receiving epidural analgesia. However, apart from providing low VAS and early extubation, TEA has not been associated with improving the perioperative morbidity or hospital length of stay.^{32,33} Liu et al performed a meta-analysis in 2004, which studied outcomes of 1,178 patients from 15 studies and found that the use of TEA led to earlier extubation (mean difference, -4.5 hours; 95% CI, -7 to -2; $p < 0.0005$) and improved pain scores at rest and with activity compared with GA alone.³⁴ Moreover, lower VAS is reported only for the immediate postoperative period (ie, up to postoperative day two, after which the analgesia is similar to that of intravenous opioids). Another major advantage of TEA is the prevention of chronic pain, which may occur after cardiac surgery. Regional analgesia with local anesthetics, particularly TEA, remains the gold standard for postoperative analgesia, as shown in most of the published studies.^{31,33}

STRESS-RESPONSE ATTENUATION

Nonanalgesic benefits of epidural analgesia have been studied in the form of stress-response attenuation. Various biomarkers, such as epinephrine, norepinephrine, interleukins, cortisol, or other cardiac enzymes, can be assessed in relation to cardiac sympathectomy. Continuous infusion of local anesthetic through epidural route has been associated with better perioperative stress-response attenuation in cardiac surgery.^{35,36} Stress-response attenuation will lead to better hemodynamic stability; however, its beneficial effect on overall outcome is yet to be demonstrated clearly.

A recent study evaluated the effect of TEA on stress hyperglycemia and the use of insulin in the perioperative period; results in the TEA group showed that, in addition to TEA providing good analgesia, blood sugar levels were lower with a decreased requirement for insulin in the postoperative period.³⁷

EPIDURAL AND SUPRAVENTRICULAR ARRHYTHMIAS

TEA-induced cardiac sympathectomy is associated with increase in myocardial perfusion, decrease in heart rate, and systemic vascular resistance and maintenance of myocardial oxygen balance.³⁸ Porizka et al reported significantly lower incidence of supraventricular arrhythmia like atrial fibrillation in patients undergoing awake CABG under TEA alone compared with GA (23.5% v 66.7%, $p < 0.05$).³⁹ Liu et al also reported decreased arrhythmias with TEA (OR 0.52; 95% CI 0.29-0.93; $p = 0.03$), although there were no significant differences in incidence of myocardial infarction and mortality.³⁴ Antiarrhythmic effect of TEA has been attributed to clonidine when used as an adjuvant.⁴⁰

FAST-TRACKING

Fast-tracking in cardiac surgery is now a trend all over the world to make it cost effective. All the potential advantages, such as early extubation, decreased arrhythmia, and enhanced analgesia, are the hallmarks of fast-tracking in cardiac surgery. TEA is an important component of fast-tracking in cardiac surgery. The beneficial effects of TEA, such as incisional and visceral nociception, early extubation and removal of chest drains and catheters, early mobility, and early discharge from the ICU, may help in fast-tracking. However, TEA does not affect the overall morbidity and length of stay in the hospital, as reported by some authors.^{32,33} Thus, actual benefit in terms of fast-tracking is limited only to the ICU. There is currently no evidence to suggest that the use of TEA is associated with earlier hospital discharge, although this may be confounded in part by the populations studied.^{7,41} Currently, the hospital length of stay is short (eg, 5 days postoperative, particularly after OPCAB, and a few hours early extubation), and ICU stay may not affect total hospital length of stay.

TEA IN MINIMALLY INVASIVE SURGERY

Minimally invasive cardiac surgery uses nonsternotomy incisions, such as thoracotomy, or ministernotomy. Thoracotomy involves costal cartilage trauma and damage to ribs, bones, or peripheral nerves that may cause intense pain. Post-thoracotomy pain may cause alteration in respiratory mechanics and lead to hypoxia and pulmonary complications. TEA can

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