# Central Neuraxial Analgesia in Cardiac Surgery

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**Abstract**

An ideal anesthetic for cardiac surgery should provide intraoperative cardiovascular stability and a stable and pain-free recovery. High-dose narcotics, whether given as an initial bolus or by the continuous infusion method, certainly have brought current practice closer to this ideal. Central neuraxial analgesia is an alternative to high-dose narcotics, but its use has long been an issue of debate and concern in cardiac surgery. The need for full heparinization for cardiopulmonary bypass has curtailed the use of central neuraxial blocks. Until fairly recently, very few centers dared to attempt this kind of effective analgesia in cardiac surgery. However, during the last few years more and more reports have been published on the efficacy and safety of this type of analgesia when appropriate precautions are taken. The objective of this report is to examine some of these issues.
**Key Words:** Central neuraxial analgesia, cardiac surgery.

## The Need for Pain Relief

IN THE POSTOPERATIVE PERIOD, it is necessary to ensure adequate respiration by clearing bronchial secretions. There is also a paramount need for the relief of pain, which may be a primary cause of postoperative complications (1, 2).

Impairment of lung function, particularly oxygenation of the blood, is a common and potentially serious complication after cardiac surgery. It has been shown to persist for as long as a week after the operation. It presents frequently with a reduced arterial oxygen tension and hemoglobin oxygen saturation when breathing room air (3– 5). Some proposed mechanisms are leukocyte activation (6), effects of anesthesia and muscle paralysis (7, 8), sternotomy (9), pleurotomy (10), extracorporeal circulation (ECC) (11, 12), accumulation of extravascular lung fluid (13) due to alterations of the alveolar-capillary membrane (14, 15), lung collapse during ECC (16), atelectasis (17), phrenic nerve paralysis secondary to topical cooling of the heart (17), altered mechanics of the rib cage (9, 18), retention of airway secretions consequent to insufficient cough due to pain (19), and postoperative hypoventilation. Atelectasis is the most important cause of postoperative morbidity and occurs in nearly all patients undergoing thoracotomy (20). Large densities in dependent lung regions were seen in most patients by computed tomography (21) on the first day after cardiac surgery. Postoperative respiratory abnormalities found after abdominal or thoracic surgery have a restrictive pattern, with decreased vital capacity and functional residual capacity (22). The desired objective of limiting the extent of decreased pulmonary function would be a worthy goal if effective pain relief could be achieved without respiratory depression.

Since it has also been shown that postoperative myocardial ischemia has a high predictive value for myocardial infarction, providing effective analgesia might reduce this risk (23).

## Effectiveness of Intrathecal Morphine

The discovery of opioid receptors in the substantia gelatinosa of the spinal cord has fostered new options for the effective management of postoperative pain (24).

Intrathecal morphine (ITM) provides very powerful postoperative analgesia of impressive duration with little disturbance of consciousness (25). A unique advantage of ITM is that morphine can be injected at a lumbar site and then diffuse into the thoracic portions of the spinal cord to provide pain relief (11). There is ample evidence that ITM produces good analgesia (22, 26, 27), and is superior to IV morphine for patients undergoing coronary artery

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bypass grafting (CABG) (28, 29). In Fig. 1, the results of three different studies are compared. One group of patients received ITM in addition to the standard narcotic-based anesthetic whereas the control group received only a narcotic-based anesthetic. The data from the ITM group reveals that the cumulative amount of morphine administered during the first 24 hours after surgery was significantly less than that required by the control group.

There is little apparent intraoperative hemodynamic difference between CABG patients receiving ITM 0.5 mg and those receiving a standard narcotic anesthetic (30). ITM does not suppress hyperdynamic responses per se, unless supplemented with a local anesthetic. Kowalewski et al. (31) showed that the combination of ITM and bupivacaine limited hyperdynamic responses to sternotomy and surgery by achieving a cardiac sympathectomy.

In the postoperative period, patients who received ITM had significantly less need for vasodilators. Fig. 2 compares the percentage of patients who received vasodilator therapy during the first 24 hours postoperatively and those who did not. Vanstrum et al. (30) reported a 35% reduction in the use of sodium nitroprusside. Patients who received ITM or thoracic epidural analgesia (see below) had less need for vasodilators. This suggests that patients who received ITM were more hemodynamically stable during this postoperative period than those patients who had received ITM. The need for fewer infusions of vasoactive drugs decreases the chance of a medication error and reflects a generally more benign course.

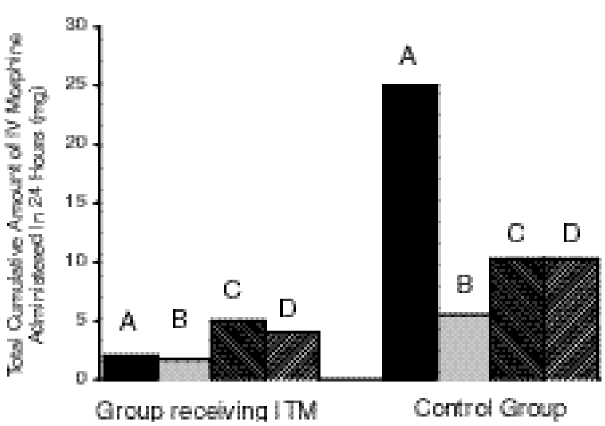


**Fig. 1.** The total cumulative dose of morphine (mg) administered intravenously during a 24-hour period as reported by three groups of investigators. Data depicted by the bars labeled A are those reported by Shroff and Bishop (34). An ITM dose of morphine of 0.01 mg/kg morphine was administered and the difference is significant ($p<0.01$). Data illustrated by the bars labeled B are those reported by Vanstrum, Bjornson and Ilko (30). An ITM dose of morphine of 0.5 mg morphine was administered and the difference is significant ($p<0.05$). Data shown by the bars labeled C and D, are those reported by Fitzpatrick and Moriarty (29). Those patients whose data are included in the bars labeled C received an ITM dose of morphine of 1 mg ($p<0.01$), while those whose data are included in the bars labeled D received 2 mg ($p<0.01$).

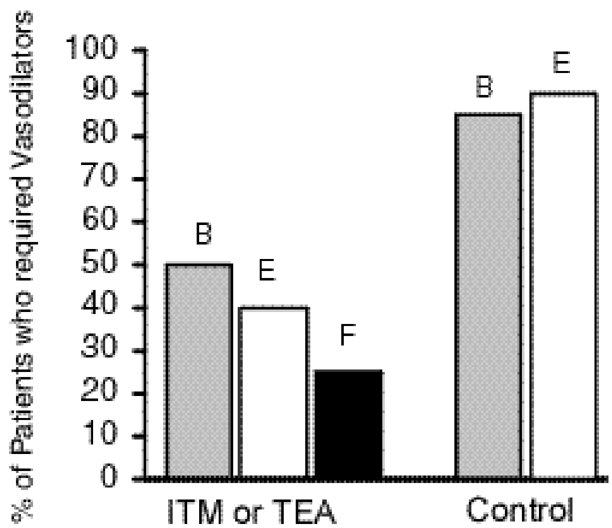


**Fig. 2.** The percentage of patients who required vasodilators. Data illustrated by the bars labeled B are those reported by Vanstrum, Bjornson and Ilko, see Fig. 1. (30) ($p<0.05$). Data shown by the bars labeled E are those reported by Liem et al. (37). In these patients, TEA was administered together with general anesthesia. The TEA infusion included bupivicaine 0.125% and sufentanil 1:1,000,000, and was administered at 0.05 mL/cm body length /hr adjusted to a VAS pain score less than 6. Their control group did not receive TEA. The difference is significant ($p<0.05$). Data depicted by the bar labeled F, were reported by Taylor et al. (32). These patients received an ITM dose of morphine of 0.03 mg/kg. A control group was not included.

### Respiratory Depression

The merits of ITM have been offset by the increased incidence of late respiratory depression. Since CABG patients generally spend the first 24 hours postoperatively in intensive care, adequate monitoring and skilled staff can deal with this problem safely and rapidly should it be necessary to do so.

The rostral spread of morphine in the subarachnoid space to the cisterns and then to the pons is thought to be responsible for the diminished respiratory drive (24). The reported incidence of respiratory depression is 0.36 – 1.9% (24, 32). This rostral spread may also cause drowsiness (33). In one study, the time to extubation was not significantly altered by ITM use (30), and, in some reports, it was improved (29, 34). Peak expiratory flow rates were also improved (29). Arterial blood gas result trends were favorable, but these did not reach statistical significance (30). There is evidence to suggest that the incidence of side effects, particularly respiratory depression, is related to the dose of ITM. Samii et al. (35) and Gjessing and Tomlin (25) observed that respiratory depression after ITM is dose-related. Consequently, the current tendency is to use lower doses. Early reports of ITM involved doses as high as 20 mg (35), but now the reported ranges are generally 5–30 μg/kg for patients undergoing heart surgery. If respiratory depression occurs, intravenous naloxone is the treatment of choice, since the cautious administration of naloxone does not alter the quality of analgesia. This phenomenon has been observed by several investigators (29, 36). This persistence of analgesia and the improvement in ventilation probably result from lower concentrations of morphine near the respiratory centers than in the vicinity of the spinal cord, and may be associated with the local analgesic action of ITM.

## Thoracic Epidural Analgesia

Thoracic epidural analgesia (TEA) is another option for the management of postoperative and intraoperative pain. TEA offers several benefits: it reduces perioperative stress, the incidence of myocardial ischemia and postoperative pain, and it is also likely that it reduces complications (25). “Fast-tracking” is enhanced, awakening and extubation occur earlier, breathing is facilitated, and patients can be mobilized sooner (37).

The use of TEA for intraoperative and postoperative analgesia, when compared with IV analgesia, provides significant improvement of perioperative pulmonary function (1). This improvement is attributed to better pain relief and to the increased postoperative alertness of patients receiving TEA (2). It also produces less depression of the ventilatory response to carbon dioxide and less atelectasis than IV morphine in non-cardiac thoracic surgery (38, 39). Liem et al. (37) found that $P_aO_2$ was significantly higher in a group of patients treated with TEA following CABG.

Joachimsson et al. (40) described how, in patients with TEA that were efficiently rewarmed, extubation of the trachea could be performed within the first 2 postoperative hours after CABG without increasing metabolic and ventilatory requirements.

There are several indications that TEA improves the myocardial oxygen supply-demand balance. A lower incidence of myocardial ischemia was observed in TEA patients compared with general anesthesia (GA) patients after CABG (37). Kock et al. (41) observed less ST segment depression in the electrocardiogram during exercise in patients with TEA. In another study, it was shown that regional cardiac sympathetic blockade with TEA that included the T1–T4 segments, increased the diameter of stenotic epicardial coronary arteries significantly ($p<0.01$), without causing dilation of coronary arterioles (42). In dogs, cardiac sympathetic blockade reduced myocardial ischemia, improved ischemic zone perfusion and reduced infarct size (43). TEA can be used to provide pain relief in patients with acute myocardial infarction or unstable angina pectoris, with acceptable hemodynamics (44, 45). Both blockade of nociceptive afferent nerves and relief of myocardial ischemia may contribute to the relief of angina (45). It also improves left ventricular global and regional wall motion abnormalities and ST segmental changes (41).

## Thoracic Epidural Analgesia versus Intrathecal Morphine: A Comparison

TEA and ITM reduce postoperative pain, levels of stress, serum cortisol levels, and the need for antihypertensive drugs after CABG. When ITM was supplemented with local anesthetics, or TEA was added to GA, hemodynamic stability was improved and the stress response to sternotomy was attenuated (31, 46). ITM has some advantages over TEA: simplicity, reliability, low dose requirements, and the absence of the need to place a catheter in the epidural space, but has the disadvantage of possible respiratory depression.

The unique pharmacokinetic aspects of the epidural space complicate the epidural administration of opioids. For example, systemic absorption and sequestration into epidural fat will influence the amount of drug that reaches receptors in the spinal cord by diffusion across the dura mater. To offset the effects of systemic absorption and fat sequestration, the epidural dose of opioids is about 10–16 times greater than that required for subarachnoid injection (47).

Several studies confirm that the duration and quality of analgesia after intrathecal opioids equal or exceed those produced by epidural administration of morphine. In these same studies, evidence of depression of ventilation occurs after epidural morphine (5 mg) but not after intrathecal morphine (250 μg), despite the fact that mean duration of analgesia (28 hours for post-caesarian section pain) produced by the lower dose of morphine exceeds that which followed the epidural injection (22, 47 – 50). These facts suggest that TEA, to be effective in cardiac surgery, needs to be based on local anesthetic infusion and not on epidural morphine. Therefore, the placement of the catheter must be in the high thoracic region, a procedure that is technically more challenging than a lumbar intrathecal injection. If local anesthetics are used, TEA, unlike ITM, provides sympathetic blockade and coronary vasodilatation as noted previously. TEA also allows for continuous analgesia beyond 24 hours, in contrast to the single injection ITM technique.

## Neuraxial Hematoma and Heparinization

The use of ITM or TEA in patients undergoing cardiac surgery is well established. Since these patients are heparinized intraoperatively, its use remains controversial. Lumbar subarachnoid puncture or thoracic epidural placement followed by heparinization may result in a neuraxial hematoma, with the potential for permanent neurologic damage (51). This fear has so far restricted the use of ITM and TEA in cardiac surgery, but the risk may not be as great as previously believed (30, 40, 46, 52). The true risk may never be established precisely due to the rarity of the event (51).

Several factors are known to increase the risk of hematoma development after lumbar puncture. These include the skill with which the procedure was performed, the number of attempts made, whether the tap was traumatic, the size of the needle used, and concomitant coagulopathy or anticoagulant therapy.

Owens et al. (51) described a patient who was heparinized 135 minutes after a technically difficult diagnostic lumbar puncture. Sixteen hours later, the patient became paraplegic. In a literature review, Owens found 33 cases of neuraxial hematoma reported since 1911, 79% involving patients with evidence of hemostatic abnormality from anticoagulation, thrombocytopenia, coagulopathy, or antiplatelet therapy (71).

Rao and El-Etr (53), and Matthews and Abrams (54) demonstrated that a decision to postpone surgery after a difficult or traumatic (bloody) tap, and subsequent care in performing the spinal tap, avoided the occurrence of subarachnoid hematoma. In their respective studies, they investigated 847 patients who had continuous spinal anesthesia and 3164 patients who had continuous epidural anesthesia that was initiated prior to heparinization for vascular surgery. A large 17-gauge Tuohy needle was used to place the catheters in both studies.

The size of the needle was not reported by Owens et al. (51). The use of 25- and 27-gauge needles is relatively recent. One could speculate that the already rare complications reviewed by Owens et al. might be further reduced by the current use of smaller gauge needles in combination with the cautious technique described by Rao and El-Etr.

In another review covering the years 1906 through 1994, Vandermeulen et al. (55) found 61 reported cases of neuraxial hematoma after central nervous block. Of these, 42 patients had impaired coagulation. Despite this, epidural techniques were used in combination with heparin anticoagulation in four large series, for a total of 5776 cases, without any report of permanent neurologic sequelae (53, 56 –58). It was also used in conjunction with cardiac surgery in several smaller (30, 40, 46, 52, 59, 60) and one large (61) study, without complications. In this larger study, Sanchez and Nygård (61) examined outcomes in 558 CABG patients who received TEA and found no occurrence of epidural hematoma. Stenseth et al. (62), and Joachimsson et al. (40), have described the use of high thoracic epidural catheter placement during CABG. They found no neurological sequelae when the catheter was inserted 20 – 24 hours prior to heparinization, and when there were no coagulation disorders at the time of catheter insertion and removal. Taylor et al. (32) reported the use of ITM in more than 10,000 cardiac surgery patients during a 20-year interval in whom there was no evidence of a spinal hematoma.

## Conclusions

The utilization of TEA or ITM for cardiac surgical patients provides benefits in perioperative pain control and lung function, and it presumably decreases morbidity secondary to respiratory complications. These techniques are associated with improved hemodynamics and myocardial oxygenation, early awakening and extubation. The potential risk of a neuraxial hematoma is of concern, and its real incidence, probably lower than previously thought, will require further study.

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