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REVIEW

# Fast-Tracking Cardiac Surgery

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## ABSTRACT

A "fast track" approach to cardiac surgery can be defined as a perioperative process involving rapid progress from preoperative preparation through surgery and discharge from the hospital. Although highly individualized among the various heart surgery centers, the fast-track process is a team activity. It requires a team of health care providers to interact with the patient at various phases, from admission to discharge. The necessary elements of the fast-track program are choice and the titration of short-acting anesthetic drugs, standardized surgical procedures, early extubation, rewarming and sustained postoperative normothermia, postoperative pain control, early ambulation, alimentation and discharge, and follow-up after discharge. We review the current approaches to some of these aspects of patient care.

## INTRODUCTION

Although the main aim of the "fast track" approach is to help patients recuperate more rapidly and shorten the period of critical care that is needed, the approach has gained widespread attention because of its benefit of decreasing the length of hospital stay. In an attempt to achieve rapid sustained recovery after open heart surgery, Krohn and colleagues employed a unique protocol during the late 1980s, which was later popularized in the 1990s by Engelman and associates [Krohn 1990, Engelman 1994, Cheng 1996b].

Cardiac surgery is estimated to cost $27 billion annually in the United States and is a burden on the health care budget [Engoren 2001]. Most of this burden is due to extended postoperative stays in the intensive care unit (ICU) and the hospital. In the United States, cost has been equated to the length of hospital stay. Hence, a decrease in hospitalization time leads to a reduction in cost and less stress on the heath care system. A desire to reduce hospital cost has prompted the development of clinical practice guidelines. These guidelines to streamline cardiac surgical procedures are multifaceted. The first fast-track protocol adapted at the Baystate Medical Center and Hartford Hospital involved the following principles: admission to the hospital on the day of surgery, extensive preoperative education of the patient and the family, use of short-acting anesthetic agents, limitation of perioperative fluid administration, early extubation, administration of steroids to patients undergoing operations on cardiopulmonary bypass, appropriate gastrointestinal prophylaxis, reduction or elimination of the ICU stay, encouragement of early mobilization and rehabilitation, and early discharge [Engelman 1994, Borst 1999, Lake 2000, Straka 2002].

## FAST-TRACK ANESTHETIC TECHNIQUE AND EARLY EXTUBATION

Fundamental principles of anesthesia for coronary artery bypass surgery include maintaining hemodynamic stability and minimizing myocardial ischemia [Myles 1997]. Traditional anesthetic techniques used before the advent of the fast-track approach aimed to decrease cardiovascular stress during heart surgery, so-called stress-free anesthesia. This anesthesia technique consisted of the administration of high-dose narcotics and long-acting muscle relaxants to obtund the nonconscious physiologic response to pain. Pain is a well-known cause of adrenergic response that further increases both myocardial and global oxygen consumption. Available short-acting anesthetics were considered to cause myocardial ischemic side effects that could possibly lead to hemodynamic instability. Because of the long-acting nature of opioid-based anesthesia, a mandatory period of postoperative ventilation in an ICU environment was required. Fast-track anesthesia avoids high-dose, long-acting narcotic techniques and effectively manages postoperative pain. Various anesthetic strategies have been tried by different investigators. Cheng and colleagues [Cheng 1996a] and later Myles and coworkers [Myles 1997] achieved success with a propofol-based technique. Soon, propofol became a major component of fast-track cardiac anesthesia and is still widely used for induction

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and maintenance as well as for sedation in the ICU [Djaiani 2001]. The major benefit of propofol compared with large-dose opioid anesthetics is the significant reduction in the recovery time leading to a decrease in the time to tracheal extubation [Cheng 1996a, Myles 1997]. However, the use of propofol is marred by undesirable hypotension in the patient and other hemodynamic side effects [Boer 1990, Bell 1994]. Engoren and associates [Engoren 1998] suggested that a fentanyl/isoflurane technique could achieve the same prompt extubation times as propofol at a much lower anesthetic cost and without the undesirable hemodynamic effects. However, 3 to 5 hours of postoperative artificial pulmonary ventilation and a 24-hour ICU stay were still required [Engoren 2001]. With the advent of minimally invasive cardiac surgery, expectations to curtail even this period of artificial ventilation were high. Ultrafast-track anesthesia (UFTA) was pioneered to meet this demand. UFTA is defined as an approach that results in extubation immediately after surgery and an earlier discharge from the hospital [Engoren 2001]. Remifentanil, an ultrashort-acting opioid, was introduced into anesthesia practice in 1993 [Glass 1993]. This drug permits more prompt extubation than fentanyl and sufentanil but is much more expensive [Engoren 2001]. It has some unique qualities that make it most suitable for UFTA. The analgesic actions of remifentanil are rapid in onset and in offset. When used as a component of an anesthesia technique, remifentanil can be rapidly titrated to the desired depth of anesthesia and analgesia by changing the continuous infusion rate or by administering a bolus injection. Ahonen et al [Ahonen 2000] studied the benefits of remifentanil/propofol anesthesia in early tracheal extubation after off-pump coronary artery bypass surgery. However, Engoren and colleagues [Engoren 2001] found that although this anesthetic results in shorter stays and early extubation, its use does not translate into lower total costs compared with fentanyl and sufentanil because of remifentanil's higher cost. Some investigators have tried the UFTA technique using remifentanil/propofol anesthesia in combination with thoracic epidural analgesia in conscious patients [Karagoz 2000, Anderson 2001]. Recently, Straka et al [Straka 2002] achieved successful extubation in 94% (n = 160) of patients in the operating room within 10 minutes of skin closure with the use of less-invasive cardiac anesthesia avoiding thoracic epidural analgesia. However, it should always be kept in mind that the cost and length of hospital stay depend on many other factors besides the choice of anesthetic agent.

The fast-track approach has modified the early time-based weaning protocol, in which the patient is sedated and ventilated overnight and weaned from mechanical ventilation the following morning, to a physiology-based protocol. In a physiology-based protocol, patients are weaned and extubated on the basis of specific physiologic parameters, such as body temperature, mental status, and pulmonary function, instead of the time course. A major component of fast-tracking is early extubation, which can vary from extubation in the operating room to extubation within the first 8 postoperative hours in the ICU. Regardless of the timing of extubation, the patient must meet standard respiratory, hemodynamic, and temperature criteria before being weaned. Some benefits of early extubation and early discharge are a decrease in morbidity, early ambulation, and a decrease in the duration of mechanical ventilation. This procedure also reduces the complications related to extended intubation, such as infections, anxiety, and psychosis. In addition, the procedure prevents complications due to prolonged immobilization, such as venous thrombosis and pulmonary emboli [Kaplan 2002].

Another significant morbidity associated with cardiac operations is postoperative myocardial ischemia. Despite having undergone successful revascularization, patients who have had cardiac operations have had postoperative ischemia documented by continuous electrocardiography [Cheng 1996b]. Mangano and coworkers [Mangano 1992] suggested that intensive analgesia is essential to reduce this postoperative myocardial injury, but such treatment requires the patient to remain intubated and ventilated for 12 to 24 hours after surgery [Cheng 1996b]. Various groups have studied the effect of early extubation on postoperative myocardial ischemia. Although Cheng et al [Cheng 1996b] and Berry et al [Berry 1998] found no significant differences in the incidence of postoperative ischemia, Barham and colleagues [Barham 1998] found a temporal relation between ST-segment changes on the electrocardiogram and the tracheal extubation time after cardiac surgery. A postoperative decrease in the left ventricular ejection fraction compared with preoperative values has also been noted after successful revascularization procedures [Mangano 1985]. It has been shown that patients who are extubated in the first few hours after cardiopulmonary bypass may look good but have both functional and metabolic compromise of the myocardium [Okutani 1988, Svedjeholm 1991]. Delaying extubation to 3 to 4 hours after the operation minimizes not only the risks of cardiorespiratory instability but also those risks associated with bleeding. On the other hand, early extubation decreases iatrogenic complications associated with mechanical ventilation and the lengths of stay in the ICU and hospital. The advent of minimally invasive surgical techniques and UFTA has rejuvenated the debate on early or late extubation, with patients being extubated in the operating room within 10 minutes of skin closure.

## REWARMING AND SUSTAINED POSTOPERATIVE NORMOTHERMIA

Temperature variation during cardiac surgery is common in most patients. It depends on the baseline temperature and is directly proportional to the duration of surgery unless active measures are taken to preserve the body temperature [Djaiani 2001]. Systemic normothermia is a requirement for extubating a patient after cardiac surgery, as it is for any other surgical patient. Warm cardiac surgery has been shown to facilitate early extubation in patients undergoing on-pump coronary artery bypass grafting [Nesher 2002]. Although physiologic derangements following cardiopulmonary bypass have been reduced by off-pump surgery, off-pump coronary artery bypass has been associated with aggravation of the hypothermia caused by the cardiac operation. This effect is due to the lack of the cardiopulmonary bypass rewarming system during off-pump coronary artery bypass surgery. There are limited data on temperature management during off-pump coronary artery bypass and early extubation or the fast-track recovery approach [Donias 2002, Nesher 2002]. Frank and associates [Frank 1997] have shown that patients with coronary artery disease who underwent major cardiac or noncardiac operations and had a mean core temperature of 35.4°C had a significantly higher incidence of myocardial ischemia, ventricular tachycardia, myocardial infarction, and cardiac arrest than patients with a mean core temperature of 36.7°C.

## POSTOPERATIVE PAIN CONTROL

Undertreated surgical pain prolongs recovery and may result in multisystem complications [Kehlet 1982, Heller 1984, Page 1997, Richardson 1998]. Effective coughing and deep breathing are major factors required for weaning the patient from mechanical ventilation, extubation, preventing atelectasis, and minimizing the possibility of pneumonia in patients undergoing thoracic surgical procedures. Adequate pain control is essential to this process [de Leon-Casasola 1994a, de Leon-Casasola 1994b]. Epidural infusion of opioids along with dilute concentrations of local anesthetic agents has been very effective in decreasing postthoracotomy pain and related complications [de Leon-Casasola 1994a, de Leon-Casasola 1994b, White 1995, Carpenter 1996]. However, because of the risk of peridural hematoma secondary to systemic anticoagulation therapy in these patients, anesthesiologists have been reluctant to place epidural catheters [Leicht 1993]. The recent interest in rapid recovery and early ambulation of patients (fast-tracking) after cardiac surgery has prompted many clinical cardiac anesthesiologists to use neuraxial analgesia for these procedures [Fitzpatrick 1988, Chaney 1997].

The use of intrathecal injection for postoperative pain control is not a new concept. High-dose intrathecal morphine administration (in the range of 1-4 mg) has been used after cardiac surgery with a resulting improvement in the quality of pain relief and pulmonary function [Aun 1985, Fitzpatrick 1988]. However, the use of high doses of morphine may prolong the extubation time. The patients in these studies were electively ventilated overnight, postoperatively.

Recently, we reviewed the cases of 125 patients who underwent coronary artery bypass grafting procedures, and the results revealed that postoperative pain was significantly lower in patients who received intrathecal opioids than in patients who were treated with traditional analgesic regimens. Seventy-eight percent of these patients were extubated in the operating room, with most of the remaining of patients being extubated within 6 to 8 hours following the completion of surgery (N.D.N., personal communication).

With the advent of interest in reducing variability in anesthesia technique and in facilitating early extubation and fast-tracking to reduce the length of ICU stay, we have implemented a standardized anesthesia protocol for cardiac surgery. Among our other goals, these modifications were made to improve postoperative pain management and reduce the risk of postoperative hypoventilation. The decision regarding the intrathecal dose of morphine to use in present cases was based on previously published results by Jacobson et al [Jacobson 1988, Jacobson 1989, Jacobson 1990]. The addition of shorter-acting opioids such as sufentanil and reducing the morphine dose have been suggested by other investigators [Swenson 1994].

Many anesthesiologists have been reluctant to use the neuraxial route of administration in patients who will be fully anticoagulated because of the possibility of peridural hematoma formation. The present study, however, is compatible with others that have shown that this possibility is extremely remote and that systemic anticoagulation initiated 1 to 2 hours after insertion of the spinal needle does not increase the incidence of peridural hematoma [Lumpkin 1998, Sanchez 1998]. Most of the epidural hematomas that have been reported have been in patients who underwent thrombolytic therapy or underwent anticoagulation therapy at the time of the neuraxial procedure [Dickman 1990, Onishchuk 1992, Haljamae 1996]. A possible explanation for these observations is that heparin lacks a thrombolytic effect and that the coagulation process and clot formation is completed by the time of systemic anticoagulation during cardiac surgery [Turnbull 1996]. In addition, using the smaller-gauge needle for spinal injection is less traumatic than using the larger-size epidural needles [Horlocker 1997, Grady 1999].

The pharmacoeconomics of fast-tracking is a complex issue that needs careful attention. Most of the cost savings are due to decreased levels of nursing care in the ICU. The costs of nursing care do not generally change if the extubation process occurs at night or in the middle of working shifts, because there is no mechanism to accommodate an unplanned reduction in the workforce needs in the surgical ICUs. However, ultrafast-tracking by extubating the patients in the operating room can reliably predict the exact needs for the postoperative nursing care.

During the last decade, the trend in cardiac surgery has been toward minimizing patient trauma. This approach not only facilitates the fast-track care plan but also reduces the incidence of perioperative morbidity and mortality. In coronary artery surgery, the use of smaller surgical incisions and the avoidance of cardiopulmonary bypass are becoming routine [Benetti 1991, Buffolo 1996, Calafiore 1996]. Advances in surgical instrumentation and improvements in surgical techniques, such as minimally invasive direct coronary artery bypass [Kirklin 1987, Westaby 1987, Messent 1992, Moat 1993, Doty 1999] and endoscopic atraumatic coronary artery bypass grafting, have helped patients recover more quickly than in the past [Czibik 2002]. Limited skin incisions with minithoracotomy or ministernotomy, with thoracoscopic video-assisted surgery (often with robotic assistance), or with port-access cardiac surgery have also been used successfully for coronary artery and valve surgery [Mack 1997, Mohr 1998, Carpentier 1999, Mohr 1999, Chitwood 2000]. This minimally invasive approach reduces the surgical trauma to the patient, thereby decreasing the incidence of postoperative complications and shortening the duration of intensive care and the overall length of stay in the hospital.

Although the fast-track approach to the anesthesia treatment of cardiac surgery patients preceded the minimally invasive revolution in our specialty, it has become apparent that anesthesia treatment and the surgical care of our patients are inextricably related. As our procedures become less invasive surgically, the success of our technical prowess will depend on the success of patient recovery via a fast-track approach.

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