Predictors of Failure in Fast-Track Cardiac Surgery

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Objectives: **Fast-track (FT) management of cardiac surgery patients is associated with early extubation and reduced length of intensive care unit (ICU) stay, with potential benefit of reduced hospital costs. The authors examined perioperative factors and their influence on failure of FT and what implications this failure had.**

Design: **Prospective data collection from all adult cardiac surgeries between 2011 and 2013.**

Setting: **Single-institution study.**

Participants: **The study included 2,770 consecutive adult cardiac surgery patients.**

Interventions: **All participants underwent adult cardiac surgeries. Of those, 451 (16.3%) patients were selected to undergo FT management.**

Measurements and Main Results: **Failure of FT was defined as early (admission to ICU on day of surgery) or late (patients later admitted to the ICU from the ward). Univariate and multivariate regression analyses were used to identify which variables predicted FT failure. Of the 451 patients included in this study, 138 (30.6%) failed the FT, with 115 (83.3%) early failures and 23 (16.7%) late failures. Predictors of failure were reduced renal function, hypertension, age, EuroSCORE, cardiopulmonary bypass time, first lactate or base deficit after surgery (all $p < 0.01$), and cross-clamp time ($p < 0.05$). Multivariate analysis showed that the strongest predictor of failure was glomerular filtration rate (GFR) <65 mL/min/BSA (sensitivity, 54%; specificity, 61%; likelihood ratio, 1.39; area under receiver operating characteristics curve, 0.59; 95% confidence interval, 0.53-0.64). Median length of hospital stay was longer for the failed group (5 *v* 7 days, $p < 0.001$). There were no mortalities in any of the patients selected for FT.**

Conclusions: **A number of perioperative factors are associated with failure to FT, the strongest predictor being GFR. Failure to FT can lead to significantly longer hospital stay.**

KEY WORDS: cardiac surgery, fast-track, glomerular filtration rate, postoperative care

SIGNIFICANT ADVANCEMENTS have been made in the immediate postoperative management of cardiac surgery patients during the past decade. Before this time, the management of all cardiac surgery patients took place in the intensive care unit (ICU), with the mainstay of immediate treatment composed of prolonged ventilatory support as a means of achieving stability of the hemodynamic, respiratory, and coagulation systems.[1] In the 1990s, initial reports described improved outcome after noncomplicated cardiac surgery by reducing time-to-extubation.[2,3] As demand for cardiac surgery services increased and rising healthcare costs placed more pressure on physicians to reduce resource consumption,[4] attention has been given to decreasing length of ICU stay after cardiac surgery.[5] Furthermore, various institutions, including the authors' institution, have begun managing selected cardiac surgery patients in a specialized recovery unit separate from the ICU in an attempt to prevent ICU stay altogether.

Fast-track (FT) cardiac surgery aims to improve efficiency in the immediate postoperative management of patients, with early-extubation anesthesia playing a central role.[6] For successful application, the components of FT cardiac surgery include FT cardiac anesthesia techniques (including the use of short-acting hypnotic drugs and reduced-dose or ultra short-acting opioids),[7] a specialized cardiac recovery unit with nursing and medical staff trained in the management of postoperative cardiac surgery patients with a focus on early extubation, a ward with facilities and staff who can manage extubated FT patients once they meet transfer criteria on the day of surgery, and an ICU with capacity to accept FT patients who do not meet criteria for transfer to the ward. As an example of FT implementation, the Leipzig FT protocol involved changing from a longer-acting opioid regimen of anesthesia to remifentanil and postoperative management of patients in a 3-bed recovery unit.[8]

A Cochrane Database Systematic Review by Zhu et al[9] investigated the safety of FT cardiac surgery by examining 25 trials involving 4,118 patients. They compared both low-dose opioid anesthesia and time-directed extubation protocols with conventional treatment of cardiac surgery patients. Their results showed no significant difference in the risk of mortality within the first postoperative year between the early-extubation protocol and conventional treatment (RR, 0.84; 95% confidence interval [CI], 0.40-1.75). Furthermore, there were no differences in the risk of postoperative complications associated with early-extubation (eg, myocardial infarction, reintubation, acute renal failure, major bleeding, stroke, major sepsis, and wound infections). Time to extubation was reduced (by mean 7.4 hours for low-dose opioid anesthesia and by mean 5.9 hours for time-directed extubation protocols) as was the length of ICU stay (by 0.4-8.7 hours). However, FT management was not associated with reduced total length of hospital stay.[9] These findings were in agreement with a systematic, meta-analysis review by Myles et al[7] who analyzed 10 trials including 1,800 patients and showed no increases in mortality or morbidity, with significantly shorter ventilation times and ICU stay in the FT group.

In this study, the authors aimed to examine both preoperative and perioperative risk factors of failure on the FT and the implications of failure. The authors' unit has been using FT cardiac anesthesia and postoperative care since 2004. The aim

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of this FT protocol was to achieve extubation within the first 4 postoperative hours and to transfer the patient to the ward by 7:30 pm on the day of surgery. Between 2011 and 2013, the authors prospectively collected data from 451 patients selected to undergo FT management.

METHODS

Data from all adult cardiac surgeries at the authors' institution between October 2011 and October 2013 were analyzed. All consecutive patients who met inclusion criteria for the FT protocol were included in the study. All clinical data, including patient demographics, perioperative risk factors, and postoperative outcomes, were collected prospectively in the database. Data collection and analysis were approved by the authors' institutional review board. Hypertension was defined as either having a documented history of hypertension combined with oral antihypertensive treatment or newly diagnosed hypertension with blood pressure $\geq$140/90 mmHg.[10] Chronic obstructive pulmonary disease was defined according to symptoms, signs, and spirometry values[11] combined with treatment with bronchodilators and/or steroids.

Inclusion Criteria for FT Protocol

Preoperative criteria included patients with a creatinine level $<$150 μmol/L who were undergoing first-time surgery involving coronary artery bypass graft (CABG), aortic valve replacement (AVR) and CABG, atrial septal defect (ASD) repair, or minimally invasive direct coronary artery bypass (MIDCAB). Intraoperative criteria were minimal inotropic support (norepinephrine $<$0.1 μg/kg/min, dopamine $<$7 μg/kg/min) and transfer to the cardiac recovery unit by 3 pm to allow enough time for extubation before transfer to the ward (the cardiac recovery unit is staffed from 8 AM to 9 PM).

Anesthetic Technique

All clinicians maintained the principles of FT anesthesia, which include the avoidance of long-acting benzodiazepine premedication or opiates, and muscle relaxants. Anesthesia was induced using fentanyl (3-8 μg/kg), propofol (1-2 mg/kg), and rocuronium (0.5-1 mg/kg). Anesthesia was maintained using isoflurane (minimum alveolar concentration, 0.5-1.0), with a propofol infusion during cardiopulmonary bypass (CPB) at a rate of 3-4 mg/kg/h. Processed electroencephalography was used frequently to titrate depth of anesthesia. After CPB, recruitment maneuvers were performed to prevent atelectasis, and multimodal warming devices were used to prevent hypothermia. After closure of the sternum the anesthetic depth was reduced to allow the patient to initiate ventilation and the patient was weaned to a pressure-assist mode before transfer to the recovery unit.

Cardiac Recovery Protocol

After the patient was admitted to the recovery unit, analgesia was maintained using a morphine infusion and regular intravenous acetaminophen (1 g/6 h). Patients were weaned from sedation and ventilation as early as possible, provided there was minimal bleeding within the first hour (chest tube drain output $\leq$100 mL/h), and core body temperature was maintained at $>$36°C.

Discharge to the ward was deemed safe after a minimum period of 1-to-1 nursing care of 6 hours (the patient having been weaned from ventilation for at least 1 hour). In addition, patients were required to be fully responsive and their pain well controlled before discharge to the ward. Other criteria for transfer to the ward included $PaCO_2$ 4-7 kPa (30.0-52.5 mmHg); $PaO_2 \geq$ 10 kPa (75.0 mmHg) on $FIO_2 \leq 0.6 \pm$ C-PAP $\leq$5 cmH_2O (only for obstructive sleep apnea patients); respiratory rate of 12-20/min; systolic BP within prescribed parameters/within 20% of preoperative values (receiving nitroglycerin $<$20 mg/h, norepinephrine $<$0.1 μg/kg/min, dopamine $<$7 μg/kg/min); stable rhythm (sinus/paced/AF [if established preoperatively]) with stable blood pressure; lactate $<$3 mmol/L; base deficit $<$-5 mEq/L; blood glucose well controlled between 5-8 mmol/L; chest tube drain output $\leq$100 mL/h; urine output $\geq$0.5 mL/kg/h; and temperature $\geq$36.0°C. Once transferred to the ward, patients were managed with a nurse-to-patient ratio of 1:4, with invasive arterial and central venous monitoring for a minimum of 6 further hours. This was the same ward to which patients were transferred after discharge from the ICU.

Study Endpoints

In this study, FT management was defined as postoperative transfer to the cardiac recovery unit (which is part of the operating room complex, but separate from the cardiac ICU), with a focus on assessment for early extubation and transfer to the ward on the same day as surgery. The aim of the FT protocol was to prevent ICU admission altogether.

The FT protocol was deemed successful if the patient's airway was extubated in the recovery unit and the patient was transferred to the ward on the same day as surgery, with no admission to the ICU, no return to the operating room, and no mortality. Failure was defined as early or late: Early failure was described as admission to the ICU directly from cardiac recovery, which included patients who were deemed unsuitable for early extubation or who were hemodynamically/metabolically unfit for discharge to the ward. Late failure was described as patients later admitted to the ICU from the ward. Other study endpoints included mortality and time to discharge.

Statistical Analyses

Pearson Chi-square and Fisher exact tests were used to compare groups: failed FT versus successful FT. Univariate logistic regression analysis was performed on a number of preoperative, perioperative, and postoperative variables (dichotomous, categorical, and continuous data) to identify which variables were associated with FT failure. The distribution of continuous variables was assessed for normality using the Shapiro-Wilk test. Unpaired t-tests or Mann-Whitney U tests were used to compare both groups. Variables found to show statistical significance ($p < 0.05$) then were included in multivariate logistic regression analyses. Using backwards stepwise (likelihood ratio) logistic regression analysis, the most significant variables that predicted FT failure were determined.