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Fast-Track Recovery in Noncoronary Cardiac Surgery Patients

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ABSTRACT

Objective: Fast-track recovery protocols result in shorter hospital stays and decreased costs in coronary artery bypass grafting (CABG) surgery. However, data based on an objective scoring system are lacking for the impact of these protocols on patients undergoing cardiac surgery other than isolated CABG.

Methods: Between March 1999 and March 2003, 299 consecutive patients who underwent open cardiac surgery other than isolated CABG were analyzed to evaluate the safety and efficacy of fast-track recovery. The parameters evaluated as predictors of mortality, ie, delayed extubation (>360 minutes), intensive care unit (ICU) discharge (>24 hours), increased length of hospital stay (>5 days), and red blood cell transfusion, were determined by regression analysis. Standard perioperative data were collected prospectively for every patient.

Results: Seventy-two percent of the patients were extubated within 6 hours, 87% were discharged from the ICU within 24 hours, and 60% were discharged from the hospital within 5 days. No red blood cells were transfused in 67% of the patients. There were no predictors of mortality. The predictors of delayed extubation were preoperative congestive heart failure (P = .005; odds ratio [OR], 4.5; 95% confidence interval [CI], 1.6-12.6) and peripheral vascular disease (P = .02; OR, 6; 95% CI, 1.9-19.4). Factors leading to increased ICU stay were diabetes (P = .05; OR, 3.6; 95% CI, 1-12.6), emergent operation (P = .04; OR, 6.1; 95% CI, 1.1-33.2), red blood cell transfusion (P = .03; OR, 2.9; 95% CI, 1.1-7.8), chest tube drainage >1000 mL (P = .03; OR, 3.4; 95% CI, 1.1-10.2). The predictors of increased length of hospital stay were ICU stay >24 hours (P = .001; OR, 5.9; 95% CI, 2-17), EuroSCORE >5 (P = .05; OR, 1.8; 95% CI, 1-3.2), and chronic obstructive pulmonary disease (P = .003; OR, 3.7; 95% CI, 1.5-8.7). Predictive factors for transfusion of red blood cells were diabetes (P = .04; OR, 2.9; 95% CI, 1.1-8.1), delayed extubation (P = .02; OR, 2.7; 95% CI, 1.4-5.1), increased ICU stay (P = .04; OR, 2.6; 95% CI, 1-6.4), and chest tube drainage >1000 mL (P = .001; OR, 4.3; 95% CI, 2-9.3).

Conclusions: This study confirms the safety and efficacy of the fast-track recovery protocol in patients undergoing open cardiac surgery other than isolated CABG.

INTRODUCTION

Fast-track recovery protocols (FTRPs) are a sequence of applications aiming at early extubation (6-8 hours after the operation) and early discharge from the intensive care unit (ICU) (before 24 hours) and from the hospital (on postoperative day 5) [Jose 1995, Karski 1995, Royston 1998, Alhan 2003]. Studies have revealed similar reliabilities and efficacies for the standard approach and FTRP [Jose 1995, Karski 1995, Lee 1998]. The demonstration of cardioprotective effects further popularized FTRPs [Koolen 1987, Gall 1988, London 1997, Miyamoto 2000]; however, the results of FTRPs in noncoronary cardiac surgery have not been shown in detail. In this study, we investigated the applicability of FTRPs for open heart surgery patients other than those who undergo isolated aortocoronary bypass procedures.

PATIENTS AND METHODS

All 299 patients scheduled at our hospital to have open cardiac surgery other than an isolated coronary artery bypass operation were prospectively introduced to our FTRP between March 1999 and March 2003. Local institutional committee approval and informed consents were obtained from all patients for both the operation and the study. Table 1 shows the distribution of operations performed. All patients received 0.5 mg oral alprazolam (Xanax) the night before operation and 125 μg/kg intramuscular midazolam 30 minutes before the operation. In the operation theater, all patients received isotonic saline at 100 mL/hour from a venous line entered with a 16G cannula. Three derivation electrocardiograms (DII, aVF, V_5), pulse oximeter readings, and invasive arterial monitoring (with a 18G cannula) were routinely used, and a right jugular vein line with an 8F catheter introducer was inserted into each patient under local anesthesia. Induction provided with intravenously administered 50 μg/kg midazolam and 2 mg pancuronium

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Table 1. Operative Procedures*

CABG + valve, n (%)	54 (18.1)
CABG + AVR	22
CABG + mitral valve repair	11
CABG + MVR	8
CABG + AVR + root enlargement	5
CABG + Bentall procedure	4
CABG + AVR + MVR	3
CABG + AVR + mitral valve repair	1
CABG + other, n (%)	35 (11.7)
CABG + left ventricular aneurysmectomy	21
CABG + replacement of ascending/arcus aorta	10
CABG + postinfarction VSD	4
Valve, n (%)	162 (54.2)
MVR	81
Mitral valve repair	6
AVR	32
MVR + AVR	40
MVR + TVR	3
Valve + other, n (%)	41 (13.7)
MVR + tricuspid valve annuloplasty	19
AVR + replacement of ascending/arcus aorta	10
Bentall procedure	6
MVR + Bentall procedure	3
MVR + atrial septal defect	3
Other, n (%)	7 (2.3)
Left ventricular aneurysmectomy	3
Acute aortic dissection	3
Left ventricular free wall rupture	1

*CABG indicates coronary artery bypass grafting; AVR, aortic valve replacement; MVR, mitral valve replacement; VSD, ventricular septal defect; TVR, tricuspid valve replacement.

was followed by 25 to 35 μg/kg fentanyl and pancuronium to reach a total dose of 0.1 mg/kg. Endotracheal intubation was applied after a period (minimum, 5 minutes) of mask ventilation. Fifty percent oxygen, 50% nitrous oxide, and 0.7% to 1% sevoflurane were administered by ventilation when the patient was hemodynamically stable. In other patients, 50% oxygen and 50% air inhalation were preferred. All patients received 80 μg/kg midazolam per hour and a vecuronium infusion as maintenance. Intravenous furosemide (0.5 mg/kg) was given when necessary. β-Blocker or vasodilator agents were preferred for the control of hypertension. The standard approach was to follow harvest of the left internal thoracic and left radial arteries with systemic heparinization to achieve activated clotting times of 450 to 500 seconds. On commencement of extracorporeal circulation, hematocrit levels were kept between 25% and 30% while mean arterial pressures were kept between 50 and 80 mm Hg with a minimum flow rate of 2 L/m^2. The adequacy of perfusion at tissue levels was indirectly monitored by using the difference in arteriovenous carbon dioxide partial pressures ($PvCO_2$ – $PaCO_2$), lactate levels, urinary output, and base deficits on blood gas analysis. The infusion rates of vecuronium and midazolam were reduced to 60 μg/kg per hour in all patients on achievement of mild hypothermia (32°C). All patients received antegrade cold crystalloid cardioplegia. All distal anastomoses were completed in a single aortic-clamp period and were followed with the completion of the proximal anastomoses with a side-biting aortic clamp and a beating heart. After the patient was weaned from extracorporeal circulation, the infusion rates of vecuronium and midazolam were lowered to 50 μg/kg per hour. Administration of both drugs was stopped on closure of the sternal skin.

Postoperative Follow-up

Each patient immediately received a warming blanket in the postoperative ICU until the patient was normothermic in the room air. Intramuscular or intravenous meperidine (0.4 mg/kg) was given to patients with uncontrolled tremors. Postoperative analgesia with intramuscular diclofenac sodium (1.25 μg/kg) was provided to all patients. Postoperative hypertensive states, particularly systolic hypertension, were treated with intravenous β-blockade (metoprolol) for patients with an ejection fraction greater than 0.40 and no bradycardia. The level of sedation was evaluated for patients still connected to a mechanical ventilator, and intravenous midazolam rather than metoprolol was given as the first choice to patients who developed an agitative state during the "awakening period." Mechanical ventilator modes were organized as synchronized intermittent mandatory ventilation plus pressure support with a respiratory rate of 12/minute, a tidal volume of 8 to 10 mL/kg, a fraction of inspired oxygen (FiO_2) of 0.6, a positive end-expiratory pressure of 0 to 5 mm Hg, a pressure support of 10 mm Hg, and a trigger sensitivity of –2 cm H_2O. Necessary modifications were applied on evaluation of routine arterial blood gas analyses. After the patient commenced spontaneous breathing, the respiratory rate on the mechanical ventilator was first diminished to 8/minute and then to 4/minute. Depending on the patient's respiratory function, including the spontaneous tidal volume, pressure support was gradually reduced to 4 mm Hg. The criteria for extubation were a conscious, hemodynamically stable patient with a PCO_2 <48 mm Hg, a pH >7.30, a PO_2/FiO_2 ratio >250, and no sign of postoperative hemorrhage and who was receiving not more than 5 μg/kg dopamine per minute. Arterial blood gases, blood glucose levels, and electrolyte levels were analyzed at 30, 60, and 120 minutes, and any necessary treatment was given. All patients were deemed for discharge to the ward between 20 and 24 hours after surgery. Postoperative chest radiographs and routine blood chemistry results were obtained on days 1 and 4. In the case of a pathologic situation, blood and/or radiographic examinations were done more frequently. As described elsewhere, all patients received a magnesium infusion as prophylaxis for atrial fibrillation [Toraman 2001]. The criteria set for patient discharge from the hospital were the presence of a normal sinus rhythm with a normal electrocardiogram, a body temperature less than 37.5°C, a hematocrit of approximately 30%, normal wound healing, and no abnormalities apparent in the chest radiograph and blood chemistry results. Normal patient mobility, which was also included in these criteria, was determined as the ability to climb stairs.

Table 2. Preoperative, Intraoperative, and Postoperative Variables of All Patients*

Age, y	55.2 ± 13.6
Female sex, n	160 (53.5%)
Diabetes, n	25 (8.4%)
Hypertension, n	9 (31%)
Chronic obstructive pulmonary disease, n	32 (10.7%)
Creatinine >2 mmol/L, n	11 (3.7%)
Peripheral arterial disease, n	13 (4.3%)
Preoperative intravenous nitrates, n	5 (1.7%)
Unstable symptoms, n	33 (11%)
EuroSCORE	5.6 ± 3.3
Cardiopulmonary bypass time, min	84 ± 37
Cross-clamp time, min	68 ± 29
Mechanical ventilation time, min	456 ± 1493
ICU stay, h	30 ± 66
Hospital stay, d	6.6 ± 5.3
Chest tube output, mL	645 ± 530
Blood transfusion, units/patient	0.86 ± 2.1
Mortality	2.7%

*Data are presented as the mean ± SD where appropriate. ICU indicates intensive care unit.

RESULTS

The EuroSCORE system was used for risk stratification [Nashef 1999]. Table 2 shows the preoperative and perioperative characteristics of the patients. Univariate analyses revealed variables that affected the duration of postoperative mechanical ventilation and the lengths of the ICU and hospital stays (Tables 3-5). The predictors of blood use and mortality are shown in Tables 6 and 7, respectively. Seventy-two percent of the patients were extubated within 6 hours, 87% were discharged from the ICU within 24 hours, and 60% were discharged from the hospital within 5 days. No red blood cells were transfused in 68% of the patients. There were no predictors of mortality. The predictors of delayed extubation were preoperative congestive heart failure (P = .005; odds ratio [OR], 4.5; 95% confidence interval [CI], 1.6-12.6) and peripheral vascular disease (P = .02; OR, 6; 95% CI, 1.9-19.4). The factors leading to increased ICU stay were diabetes (P = .05; OR, 3.6; 95% CI, 1-12.6), emergent operation (P = .04; OR, 6.1; 95% CI, 1.1-33.2), red blood cell transfusion (P = .03; OR, 2.9; 95% CI, 1.1-7.8), chest tube drainage >1000 mL (P = .03; OR, 3.4; 95% CI, 1.1-10.2). The predictors of increased length of hospital stay were ICU stay >24 hours (P = .001; OR, 5.9; 95% CI, 2-17), EuroSCORE >5 (P = .05; OR, 1.8; 95% CI, 1-3.2), and chronic obstructive pulmonary disease (P = .003; OR, 3.7; 95% CI, 1.5-8.7). Predictive factors for transfusion of red blood cells were diabetes (P = .04; OR, 2.9; 95% CI, 1.1-8.1), delayed extubation (P = .02; OR, 2.7; 95% CI, 1.4-5.1), increased ICU stay (P = .04; OR, 2.6; 95% CI, 1-6.4), and chest tube drainage >1000 mL (P = .001; OR, 4.3; 95% CI, 2-9.3).

Table 3. Predictors of Delayed Extubation (>360 Minutes) (Univariate Analysis)

Variables	P
Unstable symptoms	.001
Congestive heart failure	.002
Renal failure	.02
Peripheral arterial disease	.002
β-Blocker use	.049
Diuretic use	.03
Preoperative use of intravenous nitrates	.019
Preoperative use of intravenous heparin	.02
Nonelective operation	.009
Any red blood cell transfusion	.0001
Cross-clamp time >60 min	.004
Cardiopulmonary bypass time >100 min	.0001
Ejection fraction <0.30	.001

Table 4. Predictors of Increased Stay (>24 Hours) in the Intensive Care Unit (Univariate Analysis)

Variables	P
Unstable symptoms	.0001
Congestive heart failure	.0001
Myocardial infarction	.025
Diabetes	.0001
Preoperative intravenous nitrates	.006
Nonelective operation	.0001
Any red blood cell transfusion	.0001
Cross-clamp time >60 min	.0001
Cardiopulmonary bypass time >100 min	.0001
Ejection fraction <0.30	.002
Mechanically ventilated >6 h	0.0001

DISCUSSION

Besides its economic advantages, FTRPs are considered to cause a reduction in cardiovascular mortality [Quasha 1980], an increase in cardiac performance [Koolen 1987, Gall 1988, Miyamoto 2000], a decrease in the nosocomial infection rate [London 1997], smoother care to patients in the ICU [Midell 1974], greater patient comfort, and fewer operation cancellations due to heavy loads in the postoperative care

Table 5. Predictors of Increased Length of Hospital Stay (>5 Days) (Univariate Analysis)

Variables	P
Unstable symptoms	.0001
Chronic obstructive pulmonary disease	.0001
Nonelective operation	.0001
Cross-clamp time >60 min	.0001
Cardiopulmonary bypass time >100 min	.0001
Ejection fraction <0.30	.0001
Intensive care unit stay >24 h	.0001

Table 6. Predictors of Mortality (Univariate Analysis)

Variables	*P*
Congestive heart failure	.001
Diabetes	.01
Renal failure	.0001
Intensive care unit stay >24 h	.0001
Hospital stay >5 d	.042
Any red blood cell transfusion	.0001
Age >70 y	.04

unit [Karski 1995], compared with classic applications. Plümer et al reported in their prospective study that patients with risk factors such as a low ejection fraction, reoperation, an acute myocardial infarction within 90 days, emergency surgery, an age older than 75 years, or an extensive history of myocardial infarction can be extubated as early as patients without such risk factors and concluded that intraoperative and postoperative factors rather than preoperative factors were the predictors of delayed extubation [Plümer 1998]. They also emphasized that every patient is a candidate for early extubation in the preoperative period. On the other hand, prophylactic delay in extubation for high-risk patients does not necessarily result in a lower pulmonary complication rate [Shackford 1981]. In our study, the only predictors of prolonged ventilation were the presence of congestive heart failure and peripheral occlusive arterial disease. These findings show that early hemodynamic stability is the major determinant in the postoperative period.

Predictors of increased length of ICU stay were reported to be emergency surgery and an ejection fraction less than 0.40 [Wrong 1999], and predictors of delayed extubation were preoperative myocardial infarction and postoperatively developed renal failure [Wrong 1999]. A randomized study by Reyes et al showed that patients extubated early were also discharged early from the ICU and that early extubation did not increase postoperative complications [Reyes 1997]. Although many studies have reported the duration of mechanical ventilation to be an independent risk factor for a prolonged ICU stay, we did not observe such a relationship. This result in our study may be because more than 90% of the patients were extubated before the tenth hour after surgery.

In a report of a study in which patients were dismissed on day 4, Loubani et al advocated that the protocol is safe [Loubani 2000].

All steps of FTRP are of equal importance. Early extubation does not necessarily mean early discharge from the hospital. In our series, only 67% of the patients with a mechanical ventilation duration of less than 6 hours ($P = .001$) and 66% with an ICU stay of less than 24 hours ($P = .0001$) were discharged from the hospital on or before the fifth postoperative day.

This study shows that FTRP may also be applied to patients undergoing cardiac surgery other than coronary artery bypass grafting. We believe that every patient deserves the safety and efficacy of FTRP, regardless of the presence of any risk factors. Further studies are needed to document the economic advantages of this protocol.

Table 7. Predictors of Any Transfusion of Red Blood Cells (Univariate Analysis)

Variables	*P*
Preoperative history of congestive heart failure	.007
Diabetes	.005
Renal failure	.01
Preoperative intravenous nitrates	.04
Preoperative intravenous heparin	.04
Cross-clamp time >60 min	.003
Cardiopulmonary bypass time >100 min	.001
Age >70 y	.0001
Mechanically ventilated >6 h	.0001
Intensive care unit stay >24 h	.0001

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