Fast-track practice in cardiac surgery: results and predictors of outcome

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Abstract

OBJECTIVES: Various studies have shown different parameters as independent risk factors in predicting the success of fast-track postoperative management in cardiac surgery. In the present study, we evaluated our 7-year experience with the fast-track protocol and investigated the preoperative predictors of successful outcome.

METHODS: Between 2004 and 2010, 5367 consecutive patients undergoing cardiac surgery were preoperatively selected for postoperative admission in the postanaesthesia care unit (PACU) and were included in this study. These patients were then transferred to the ordinary ward on the same day of the operation. The primary end-point of the study was the success of the PACU protocol, defined as discharge to the ward on the same day, no further admission to the intensive care unit and no operative mortality. Logistic regression analysis was performed to detect the independent risk factors for failure of the PACU pathway.

RESULTS: Of 11,895 patients undergoing cardiac surgery, 5367 (45.2%) were postoperatively admitted to the PACU. The protocol was successful in 4510 patients (84.0%). Using the multivariate logistic regression analysis, older age and left ventricular dysfunction were found to be independent risk factors for failure of the PACU protocol [odds ratio of 0.98/year (0.97–0.98) and 0.31 (0.14–0.70), respectively].

CONCLUSIONS: Our fast-track management, called the PACU protocol, is efficient and safe for the postoperative management of selected patients undergoing cardiac surgery. Age and left ventricular dysfunction are significant preoperative predictors of failure of this protocol.

Keywords: Anaesthesia • Fast-track • Cardiac surgery • Outcome

INTRODUCTION

The advantages of early extubation after cardiac surgery have been well established [1]. Many investigators [2–5] tried to find a clinical fast-track pathway for an efficient and safe approach to the postoperative management of cardiac surgery patients. The main aim of most studies was to achieve a rapid uncomplicated recovery with minimal load on the intensive care unit (ICU) [3]. Different end-points have been used to define the success of these different pathways. Most investigators focused on ventilation time, length of ICU and hospital stay and postoperative complications as the main end-points to evaluate the outcome of fast-track management [6, 7].

In 2001, we started the fast-track protocol in our institution for selected patients undergoing cardiac surgery. These patients were managed postoperatively in a postanaesthesia care unit (PACU). The aim of this protocol was to transfer the patients postoperatively to the ordinary ward on the same day of the operation. Since 2004, we have prospectively collected the data of these patients in our computerized database. In this study, these data were analyzed to evaluate the outcome of these patients and determine the efficacy of the PACU protocol.

MATERIALS AND METHODS

This study was performed in a single centre (Catharina Hospital, Eindhoven, The Netherlands) from January 2004 till December 2010. The local medical ethics committee approved the study and waived the need for an informed consent. All consecutive patients who met the inclusion criteria and entered the PACU protocol were included in this study. Clinical data, including
demographics, risk factors and complications, were prospectively collected in our computerized database.

Inclusion criteria for the PACU protocol:

(i) Patients scheduled for isolated coronary artery bypass grafting (CABG), off-pump coronary artery bypass (OPCAB), isolated aortic valve replacement (AVR) or combined AVR with one coronary bypass graft.
(ii) Non-complex isolated cardiac surgical procedures (closure of atrial septal defect or removal of an atrial myxoma)

Exclusion criteria for the PACU protocol:

(i) Physical status class of >3 (according to the American Society of Anesthesiologists classification)
(ii) Patients undergoing reoperation.
(iii) Chronic obstructive pulmonary disease (COPD) GOLD class ≥2.
(iv) Left ventricular dysfunction.
(v) Serum creatinine of ≥150 mmol l⁻¹.
(vi) Body mass index (BMI) of ≥35 kg m⁻².
(vii) Emergency operations.
(viii) Surgical complications necessitating prolonged cardiopulmonary bypass time (CPB) (>150 min).

Anaesthetic technique

All preoperative medications were continued until the morning of the operation. Premedication consisted of oral temazepam 20 mg/oral lorazepam 2 mg (1 mg for patients >70 years old) before the night and lorazepam 2 mg (1 mg for patients >70 years old) and paracetamol 1000 mg in the morning 1 h before surgery. Anaesthesia was induced with fentanyl 6 µg kg⁻¹, etomidate 0.3 mg kg⁻¹ and midazolam 5 mg. Before intubation, rocuronium 0.4 mg kg⁻¹ was administered. Ventilation was started and sevoflurane was often added after intubation until continuous intravenous medications were administered via the central venous catheter. Maintained anaesthesia was achieved using propofol 0.06 mg kg⁻¹ min⁻¹ and alfentanil 1 µg kg⁻¹ min⁻¹. A bispectral index monitor® (Philips Medical System, Best, The Netherlands) was used to guard the depth of anaesthesia.

Postoperatively, alfentanil was stopped 15 min after arrival on the PACU. In addition, we gave 1 g tranexamic acid and 2 g cefotaxim (IV), which was continued for 24 h postoperatively. The postoperative pain management plan consisted of paracetamol and non-steroidal anti-inflammatory drugs, such as diclofenac, intravenously. No morphinomimetics were administered in the postoperative period.

Operative techniques

Normothermic non-pulsatile flow was used during cardiopulmonary bypass (CPB). According to the surgeon’s preference, cold antegrade crystalloid cardioplegia (St Thomas solution) or warm intermittent antegrade blood cardioplegia was used to induce and maintain cardioplegic arrest. All patients undergoing CABG with use of CPB received a low dose of aprotinin (2 million kallikrein-inactivating units, or KIU) administered in the priming solution for CPB. Since November 2007, aprotinin has no longer been administered perioperatively. Patients undergoing off-pump surgery did not receive aprotinin. The patient was weaned from the CPB only when the nasal temperature was ≥37.0°C and the rectal temperature was ≥35.0°C. In order to reach these levels of temperature, the patient was actively warmed using the CPB or with a bear hugger (active external warming) in case of OPCAB.

The PACU protocol

The aim of the PACU protocol was to transfer the patient postoperatively to the ward on the same day of the operation. The first scheduled patients of the day were admitted to the PACU directly after the operation. Patients were extubated on the PACU after normalization of the body temperature (rectal temperature >36.5°C), and adequate stabilization of their haemodynamic and respiratory conditions. Strictly, measurement of the haemodynamic parameters such as blood pressure, heart rate, diuresis and peripheral temperature was performed during the whole postoperative day. If any of these parameters did not meet the determined ‘protocol values’ for diuresis, haemodynamics, respiratory condition and blood loss, the patient was transferred to the ICU. If these conditions remained stable, the patients were transferred to the ordinary ward. The dedicated PACU beds were closed at the end of the day at 20.00 h. On the ward, patients received telemetric surveillance of heart rhythm, blood pressure and saturation until the following day. Blood loss via the chest tubes was carefully checked during the first 24 h. If any disturbance of a physiological parameter was recorded on the ward, an ICU physician reevaluated the patient and, if necessary, the patient was transferred to the ICU.

Transfer to the ward

Patients were transferred to the ordinary ward on the same day of the operation when the following conditions were fulfilled:

(i) Stable haemodynamic parameters without pharmacological or mechanical cardiac supports. Systolic blood pressure of >100 mmHg, diastolic blood pressure <90 mmHg.
(ii) Awake and alert patients. Patients answer questions and follow orders.
(iii) A stable sinus rhythm on the electrocardiogram without signs of ischaemia. Heart rate of <100/min. No atrial fibrillation.
(iv) Normal respiratory function with O₂ saturation of >90% with maximum 5 l supplementary oxygen through a nasal catheter, and arterial pCO₂ level of <35 mmHg on arterial blood gas analysis.
(v) Blood loss of <50 ml h⁻¹ via the chest tubes.
(vi) Urine output of >0.5 ml kg⁻¹ h⁻¹.
(vii) Temperature difference between rectal and peripheral temperatures (ΔT) of <5°C (unless the O₂ saturation of the venous blood sample was >70%).

Study end-points

The PACU short-track pathway was considered successful when the patient was transferred to the ward the same day of the operation, and there was no admission to the ICU, no take-back to
the operation room for exploration and no operative mortality or morbidity.

Statistical analyses

Univariate logistic regression analyses were performed to investigate the impact of biomedical variables on fulfilling the PACU protocol. If significant at $P < 0.05$, the variables were included into the multivariable logistic regression analyses. A $P$ value $<0.05$ was used for all tests to indicate statistical significance. Odds ratios (OR) with a confidence interval of 95% with $P$ values are reported. All statistical analyses were performed using SPSS version 15.0 (SPSS Inc., Chicago, IL).

RESULTS

During the study period (January 2004–December 2010), 11 895 patients underwent cardiac surgical procedures in our institution. Of this number, 5367 patients (45.2%) fulfilled the criteria of the PACU protocol and were included in this study. Demographic data are shown in Table 1.

The majority of the patients were males (77.3%). The most important comorbidities were diabetes (19.7%), COPD (9%), previous cerebrovascular accident (CVA) (3.6%), peripheral vascular disease (12.2%), hypertension (51.1%), renal dysfunction (2%) and BMI $>35$ kg m$^{-2}$ (3.2%). Previous myocardial infarction was present in 34.8% of the patients and 19.3% had previous percutaneous coronary intervention (PCI).

Operative data are shown in Table 2. Of the CABG patients, 713 (13.3%) were operated with the OPCAB technique. The mean number of distal anastomoses was 3.5 ± 1. None of those PACU patients has bilateral internal thoracic artery revascularization. Our strategy is to use the radial artery in case of complete arterial revascularization.

Operative mortality included 24 patients (0.4%) (Table 3). The mean duration of stay in the PACU was 6.8 ± 1.7 h. The number of patients who were transferred to the ward on the same day of the operation was 4569 (85.1%). Twenty-nine patients (0.5%) were admitted to the ICU within 12 h, 3 (0.1%) within 1 day, 26 (0.5%) within 1 week and 5 (0.1%) after the first postoperative week. The number of patients who were transferred from the PACU to the ICU was 785 (14.6%). Table 4 shows the different causes for transferring the patient to the ICU. The PACU pathway was successful in 4510 patients (84.0%).

The mean value of the length of postoperative hospital stay was 6.7 ± 5.5 days. Many patients were discharged to their own hospital on the third postoperative day for further postoperative recovery. Information is lacking about the length of stay of those patients in their hospitals.

The most important causes of hospital mortality ($n = 24$) were low cardiac output ($n = 10$), surgical bleeding ($n = 1$), sepsis ($n = 4$), multiorgan failure ($n = 1$), neurological disorders ($n = 3$) and respiratory insufficiency ($n = 1$). Four patients died after discharge from the hospital. The cause of death was not retrieved in these 4 patients.

Table 5 shows the results of the logistic regression analysis for the prediction of failure of the PACU protocol. Univariate logistic regression analysis revealed older age (OR = 0.97/year), hypertension (OR = 0.83), renal dysfunction (OR = 0.6) and left ventricular ejection fraction (EF) lower than 35% (OR = 0.32) as predictors of failure of the fast-track pathway after cardiac surgery. Both the logistic and the additive EuroSCORE are also univariate predictors of the success of the PACU protocol.

Multivariate logistic regression analysis revealed only older age (as a continuous variable) (OR = 0.98) and left ventricular EF lower than 35% (OR = 0.31) as independent predictors of failure of the PACU protocol.

Fig. 1 shows the predicted probability of the outcome of the PACU pathway according to age as a continuous variable. Older age is correlated with the higher chance of failure of the PACU pathway.

### Table 1: Demographic data and comorbidities

<table>
<thead>
<tr>
<th>Variables</th>
<th>Incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male, gender</td>
<td>4151 (77.3%)</td>
</tr>
<tr>
<td>Age (years), mean (range)</td>
<td>64.6 ± 9.6 (19–87)</td>
</tr>
<tr>
<td>Diabetes, $n$</td>
<td>1059 (19.7%)</td>
</tr>
<tr>
<td>COPD, $n$</td>
<td>482 (9%)</td>
</tr>
<tr>
<td>CVA, $n$</td>
<td>191 (3.6%)</td>
</tr>
<tr>
<td>Peripheral vascular disease, $n$</td>
<td>265 (12.1%)</td>
</tr>
<tr>
<td>Hypertension, $n$</td>
<td>2741 (51.1%)</td>
</tr>
<tr>
<td>Renal dysfunction, $n$</td>
<td>110 (2%)</td>
</tr>
<tr>
<td>EF &lt; 35%, $n$</td>
<td>27 (0.5%)</td>
</tr>
<tr>
<td>Previous myocardial infarction, $n$</td>
<td>1869 (34.8%)</td>
</tr>
<tr>
<td>Previous PCI, $n$</td>
<td>1036 (19.3%)</td>
</tr>
<tr>
<td>Logistic EuroSCORE, mean</td>
<td>2.9 ± 3.0</td>
</tr>
<tr>
<td>Additive EuroSCORE, mean</td>
<td>3.0 ± 2.2</td>
</tr>
</tbody>
</table>

Data are given as a mean ± SD or as numbers (%). BMI: body mass index; COPD: chronic obstructive pulmonary disease; CVA: previous cerebrovascular accident; EF: left ventricular ejection fraction; PCI: percutaneous coronary intervention.

### Table 2: Operative data

| CABG, $n$ | 3990 (74.3%) |
| OPCAB, $n$ | 713 (13.3%) |
| AVR, $n$   | 573 (10.7%) |
| AVR + CABG, $n$ | 47 (0.9%) |
| Use of LITA | 3937 (83.7%) |
| Number of distal anastomoses | 3.5 ± 1 |
| Left ventricular aneurysmectomy, $n$ | 4 |
| Concomitant PVISO | 61 (1.1%) |
| AVR + MORROW procedure, $n$ | 2 |
| Percutaneous resection, $n$ | 1 |
| Resection of myxoma, $n$ | 11 (0.2%) |
| Closure of ASD | 28 (0.5%) |
| CPB time, min | 60.2 ± 39.0 |

Data are number (%) or mean ± SD. AVR: aortic valve replacement; ASD: atrial septal defect; CABG: coronary artery bypass grafting; CPB: cardiopulmonary bypass; LITA: left internal thoracic artery; OPCAB: off-pump coronary artery bypass; PVISO: pulmonary vein isolation.
In this study, we confirmed the safety and efficiency of the short-track postoperative management in selected patients undergoing cardiac surgery. Advanced age and left ventricular dysfunction (i.e. EF <35%) were found to be significant predictors of failure of this fast-track pathway and transfer to the ICU.

During the study period, 5367 patients were managed according to the new PACU pathway. This number represents almost the half (45.2%) of the total number of patients who underwent cardiac surgical procedures in our institution.

In the last two decades, many centres have adopted fast-track postoperative management in order to gain beneficial effects on the costs of cardiac surgical procedures [2, 3]. Such a protocol is an efficient method to combat the problem of decreasing numbers of ICU beds and working nurses and to save costs as a result of shortened length-of-stay in expensive postoperative units [4]. The benefits of early extubation include improved cardiac function and patient comfort, reduction in respiratory complications, as well as ease in management [8]. On the other hand, the number of patients with higher risk profiles is increasing and includes older and more obese patients [5, 6]. This makes the need for a cost-effective postoperative practice after cardiac surgery an important demand.
In our hospital, we started the PACU pathway because the cardiac surgery program was hampered by the lack of sufficient ICU beds. For this purpose, we have operated on these selected patients using general anaesthesia without regional anaesthetic techniques. In this regard, different combinations of anaesthetic techniques were described [7, 9] with the aim to shorten the postoperative course of cardiac surgery patients without affecting safety. Hemmerling et al. [10] and Chaney [11] reported an epidural technique in order to facilitate early extubation and length of ICU stay. Numerous combinations of drugs and techniques have been described in order to shorten the process of fast-track anaesthesia [9–13]. However, attention should be paid to the possibility of patient awareness while using short-acting drugs. In our patients, with the use of sevoflurane and midazolam at the beginning of the procedure, no operative patient awareness was detected.

Different independent risk factors have been reported to predict failure of a fast-track process after cardiac surgery [14, 15]. Tuman et al. [16] discussed a model for stratifying the risk of serious morbidity in 3156 patients after adult cardiac surgery. Among all the preoperative factors, they identified emergency operation, type of procedure, age, renal dysfunction, CVA, reoperation, female gender and left ventricular dysfunction as significant predictors of morbidity and prolonged ICU stay. Ettema et al. [17] systematically reviewed 20 models for the prediction of prolonged ICU stay after adult cardiac surgery and concluded that the Parsonnet and EuroSCORE were superior risk models in this regard.

Some patients with left ventricular dysfunction (n = 29 (0.5%)) were managed according to the PACU protocol because preoperative evaluation of the EF was subjectively performed using left ventriculography. The result of the multivariate analysis confirms that an EF of <35% is a predictor of failure of the PACU protocol and should be rigorously respected as a contraindication for this protocol. On the other hand, 24 patients (0.4%) with an EF of <35% have completed the PACU pathway successfully. The cut-off point of 35% was arbitrary and is possibly too high to discard patients from the PACU management. In addition, the postoperative course of these patients could not be merely predicted by the preoperative value of the EF, but rather by other preoperative findings like the amount of viable myocardium and LV volume [18].

In the current study, we showed that general anaesthesia without a regional technique is sufficient for efficient adult cardiac surgery. There are important contributory factors to help the success of fast-track cardiac surgery. Pre operative screening and patient selection are critical. In addition, careful monitoring within the first 24 h postoperatively and the availability of experienced and highly trained nurses on the ward are essential to detect changes in patient’s condition on time. At the initial start of our PACU protocol, we tried to create optimal safety and provided sufficient and direct communication among all participating staff. Communication between the dedicated nursing staff on the ward and the responsible physicians is mandatory for the success of this protocol.

Many investigators have focused on the time to extubation as an important goal of the fast-track pathways [19]. This was not the case in our PACU protocol. Time to extubation itself was not critical in determining the success of the of the fast-track process. Rewarming the patient and postoperative stabilization of the haemodynamic parameters are essential before extubation [20]. As we mentioned above, the success of the PACU protocol was defined as the transfer to the ordinary ward on the same day of the operation, no admission to the ICU, no take-back to the operation room and no mortality. Many authors [21, 22] have advised early mobilization and restoration of normal physiological function after cardiac surgery. We believe that immediate restoration of normal body temperature in addition to pain-free and stress-free awakening of the patient is of utmost importance, especially in patients undergoing OPCAB surgery. In order to achieve these criteria, extubation 2–3 h after arrival on the PACU was expected. On the PACU, postoperative administration of morphine derivatives was abandoned.

In this study, advanced age was identified as a significant factor to predict failure of the PACU protocol. In contrast, an earlier study of Paone et al. [5] found no need to modify the clinical pathways according to age. However, we believe that older patients need more time to clear their body systems of the anaesthetic drugs. This can prolong the awakening times and delay the discharge of the patient from the PACU. In this case, the patient is subsequently transferred to the high-care division of the ICU to stay overnight. An important limitation of our study is that we used age as a continuous variable, without a definite cut-off point, to determine its effect on the postoperative course of PACU patients. In the study of Paone et al. [5], patients older than 70 years showed longer ICU and hospital stay than did younger patients. On the other hand, Hannan et al. [23] showed a higher incidence of readmission after isolated CABG in patients ≥80 years old than other patients. Besides age, other factors should be taken into consideration including vitality, cognitive function and renal function before accepting older patients for the PACU pathway [24].

Although lacking statistical significance, our data suggest that bleeding complications, signs of myocardial ischaemia, respiratory insufficiency and being inadequately awake were the most frequent causes for failure of the PACU protocol. Toraman et al. [25] found respiratory distress to be the main reason for ICU readmission after CABG. In their multivariate analysis, age above 65 years, peripheral arterial disease and postoperative drainage of >500 ml of blood were independent risk factors for failure of the fast-track management of CABG patients. For valve surgery, only preoperative congestive heart failure was an independent risk factor for failure of the fast-track pathway. In a study by Kogan et al. [14] found stroke, renal failure and combined procedures to be independently associated with failed early extubation and delayed ICU and hospital discharge. In their analysis, infection and atrial fibrillation were independent risk factors in predicting possible late discharge.

Limitations

This is a retrospective observational single-centre study. Therefore, we must be cautious in interpreting our results. Our findings were the result of the local hospital protocol agreed upon by a team of anaesthesiologists, ICU physicians, cardiac surgeons and nursing staff. Whether the same results can be applied to other settings remains to be investigated.

CONCLUSIONS

This study demonstrates that our fast-track management, called the PACU protocol, is efficient and safe for the postoperative management of selected patients undergoing cardiac surgery. Age and left ventricular dysfunction were the preoperative predictors of failure of the protocol.

Conflict of interest: none declared.
REFERENCES


