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Research Article

"Outcome of Fast-Track Extubation Pediatric Cardiac Surgery-A Single Center Study"

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Abstract: ***Introduction:*** The need for prolonged mechanical ventilation for children with congenital heart disease after cardiac surgery has changed with the advances in surgical and perioperative care. ***Objectives*****:** In the present study, we evaluated our six months experience with the fast-track protocol and investigated the preoperative predictors of successful outcome. ***Methods:*** Between July to December 2019, BSMMU, Dhaka, Bangladesh 60 consecutive patients undergoing cardiac surgery were preoperatively selected for post-operative 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:*** 110 patients underwent cardiac surgical procedures in our institution. The majority of the patients were males (68.4%). The most important comorbidities were diabetes (16.7%), COPD (6.7%), previous cerebrovascular accident (CVA) (5%), peripheral vascular disease (10%), hypertension (45%), renal dysfunction (1.7%) and BMI >15 kg m^{-2} (8.3%). Using the multivariate logistic regression analysis, child 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: Anesthesia, 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 m 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 ventila-tion time, length of ICU and hospital stay and postoperative management of cardiac surgery patients. The main aim of most studies was to achieve a rapid uncomplicated recovery with complications as the main end-points to evaluate the outcome of fast-track management [6, 7]. In 2015, 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

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the ordinary ward on the same day of the op-eration. Since 2015, 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. 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 child patients need more time to clear their body systems of the anesthetic 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 con-tinuous 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], patient's child than 18 years showed longer ICU and hospital stay than did younger patients. Besides age, other factors should be taken into consideration including vitality, cognitive function and renal function before accepting child patients for the PACU pathway [24].

MATERIALS AND METHODS

This study was performed in Bangabandu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh from July to December 2019. 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

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

Exclusion criteria for the PACU protocol

a) Physical status class of >3 (according to the American Society of Anesthesiologists classification)
b) Patients undergoing reoperation.
c) Chronic obstructive pulmonary disease (COPD) GOLD class ≥2.
d) Left ventricular dysfunction.
e) Serum creatinine of ≥150 mmol l^{-1}.
f) Body mass index (BMI) of ≥35 kg m^{-2}.
g) Emergency operations.
h) Surgical complications necessitating prolonged cardiopul-monary bypass time (CPB) (>150 min).

Anesthetic Technique

All preoperative medications were continued until the morning of the operation. Premedication consisted of oral temazepam 20 mg/lorazepam 2 mg (1 mg for patients >18 years) before the night and lorazepam 2 mg (1 mg for patients >18 years) and paracetamol 1000 mg in the morning 1 h before surgery. Anesthesia 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 sevo-flurane was often added after intubation until continuous intra-venous medications were administered via the central venous catheter. Maintained anesthesia was achieved using propofol 0.06 mg kg^{-1} min^{-1} and alfentanil 1 µg kg^{-1} min. postoperatively, alfentanil was stopped 15 min after arrival on the PACU. In addition, we gave 1 g tranexamic acid and 2 g cefo-taxim (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 cardiopul-monary 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. 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 post-operatively 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 haemo-dynamic 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, haemo-dynamics and 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:

a) Stable haemodynamic parameters without pharmacological or mechanical cardiac supports. Systolic blood pressure of >100 mmHg, diastolic blood pressure <90 mmHg.
b) Awake and alert patients. Patients answer questions and follow orders.
c) A stable sinus rhythm on the electrocardiogram without signs of ischaemia. Heart rate of <100/min. No atrial fibrillation.
d) Normal respiratory function with O_2 saturation of >90% with maximum 5-l supplementary oxygen through a nasal catheter, and arterial pCO_2 level of <50 mmHg on arterial blood gas analysis.
e) Blood loss of <50 ml h^{-1} via the chest tubes.
f) Urine output of >0.5 ml kg^{-1} h^{-1}.
g) Temperature difference between rectal and peripheral temperatures (T) of <5°C (unless the O_2 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 investi-gate 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 21.0 (SPSS Inc., Chicago, IL).

RESULTS

110 patients underwent cardiac surgical procedures in our institution. Of this number, 60 patients (54.5%) 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 (68.4%). The most important comorbidities were COPD (6.7%), previous cerebrovascular accident (CVA) (5%), peripheral vascular disease (10%), renal dysfunction (1.7%) and BMI >35 kg m^{-2} (8.3%). Previous myocardial infarction was present in 30% of the patients and 16.7% had previous percutaneous coronary intervention (PCI) [Table 1].

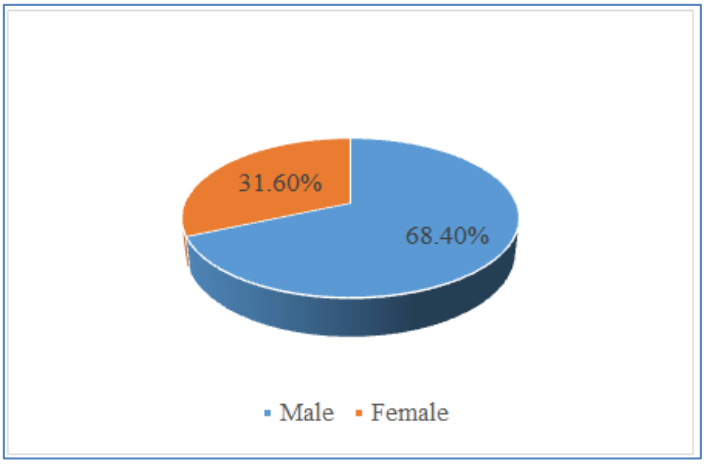

Fig-1: Sex distribution of patients

Table-1: Demographic data and comorbidities (N=60)

Variables	Incidence
Male, gender	41 (68.4%)
Age (years), mean (range)	9.5 ± 2.6 (1-18)
COPD, n	4(6.7%)
CVA, n	3(5%)
Peripheral vascular disease, n	6(10%)
Renal dysfunction, n	1 (1.7%)
BMI > 15 kg m^{-2}	5 (8.3%)
EF < 35%, n	1 (1.7%)
Previous myocardial infarction, n	18 (30%)
Previous PCI, n	10 (16.7%)
Logistic EuroSCORE, mean	2.9 ± 3.0
Additive EuroSCORE, mean	3.0 ± 2.2
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 (N=60)

CABG, n	39 (65.0%)
OPCAB, n	17 (28.4%)
AVR, n	15 (25.0%)
AVR + CABG, n	1 (1.7%)
Use of LITA	35 (58.4%)
Number of distal anastomoses	3.5 ± 1
Left ventriclular aneurysmectomy, n	1
Concomittant PVISO	2 (3.4%)
AVR + MORROW procedure, n	1
Pericardial resection, n	1
Resection of myxoma, n	2 (2.4%)
Closure of ASD	1 (1.7%)
CPB time, min	60.2 ± 39.0
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.	

Table-3: Postoperative data (N=60)

Variables	Incidence
Transfer to the ward on the same day, n	45 (75.0%)
Re-exploration, n	2 (3.4%)
Perioperative myocardial infarction, n	1 (1.7%)
Postoperative new onset AF	10 (16.7%)
Operative mortality, n	1 (1.7%)
Mean stay in PACU (h)	6.8 ± 1.7
Admission to ICU, n	
Within 12 h postoperatively	1 (1.7%)
Within the first postoperative day	1 (1.7%)
Within 1 week postoperatively	1 (1.7 %)
After the first postoperative week	1 (1.7%)
Success of the PACU protocol, n	41 (68.4%)
Postoperative hospital stay day	6.7 ± 5. 5

Operative data are shown in Of the CABG patients 65.0%, 17 (28.4%) were operated with the OPCAB technique. The mean number of distal anastomoses was 3.5 ± 1[Table 2]. 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 1 patients (1.7%) [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 45 (75.0%). Twenty five patients (41.6%) were admitted to the ICU within 12 h, 1 (1.7%) within 1 day, 10 (16.7%) within 1 week and 1 (1.7%) after the first postoperative week. The number of patients who were transferred from the PACU to the ICU was 25 (41.6%). Shows the different causes for transferring the patient to the ICU. The PACU pathway was

successful in 41 patients (68.4%).The mean value of the length of postoperative hospital stay was 6.7 ± 5. 5 days [Table 3].

Table-4: Causes for transfer from PACU to ICU (n =25)

Casus	Number	(%)
Blood loss >50 ml h^{-1}, n	4	(6.7)
Myocardial ischaemia, n	3	(5.0)
Respiratory insufficiency, n	2	(3.3)
Air leakage of the chest tube	2	(3.3)
Haemodynamically unstable, n	3	(5.0)
Not awake enough, n	4	(6.6)
Postoperative CVA, n	1	(1.6)
Other operation than planned, n	1	(1.6)
Dysrhythmia, n	2	(3.3)
No available bed on the ward, n	1	(1.6)
Others/unknown, n	2	(3.3)
Data are presented as numbers (%). CVA: cerebrovascular accident; EF: left ventricular ejection fraction.		

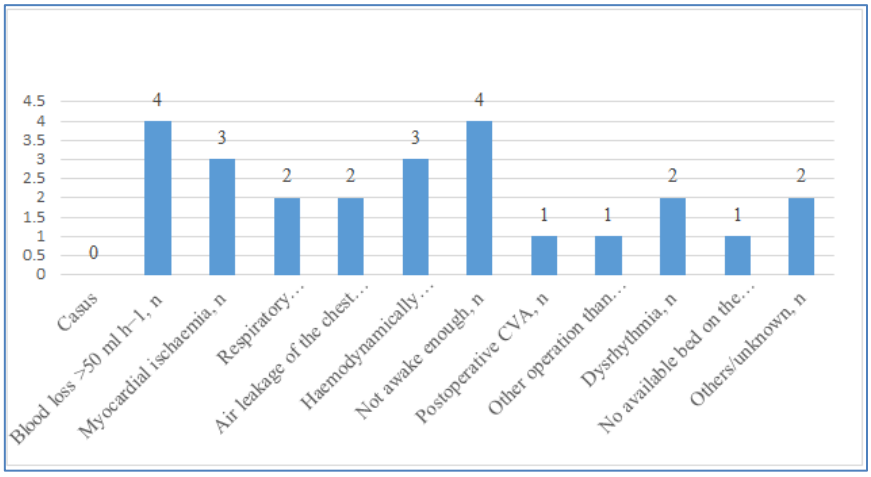

Fig-2: Causes for transfer from PACU to ICU (n =25).

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 = 10) were low cardiac output (n = 7), surgical bleeding (n = 2), sepsis (n = 2), multiorgan failure (n = 1), neurological disorders (n = 2) 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: Results of logistic regression analyses for outcome of the PACU protocol

Variables	Univariate analyses			Multivariate analysis	
	OR (95% CI)		P	OR (95% CI)	P
Male	1.18	(0.99–1.40)	0.052		
Age[a]	0.97	(0.97–0.98)[c]	<0.0001	0.98(0.97–0.98)[c]	<0.0001
COPD	0.86	(0.67–1.10)	0.239		
Peripheral Vascular disease	0.91	(0.73–1.14)	0.443		
Renal dysfunction	0.60	(0.38–0.94)	0.028	0.69(0.44–1.08)	0.111
BMI > 15 kg m^{-2}	0.89	(0.59–1.32)	0.568		
EF < 35%	0.32	(0.14–0.70)	0.004	0.31(0.14–0.70)	0.005
AVR	1.08	(0.84–1.37)	0.532		
AVR + CABG[b]	0.30	(0.16–0.54)	<0.0001		
Other procedures[b]	0.73	(0.35–1.52)	0.407		
Logistic EuroSCORE[a]	0.94	(0.92–0.97)	<0.0001		
Additive EuroSCORE[a]	0.89	(0.86–0.92)	<0.0001		
AVR: aortic valve replacement; BMI: body mass index; CABG: coronary artery bypass grafting; CI: confidence interval; COPD: chronic obstructive pulmonary disease; EF: ejection fraction; PACU: postanaesthesia care unit; PCI: percutaneous coronary intervention. [a]Entered as a continuous variable. [b] Compared with CABG. [c]OR is per year.					

[Table 5] shows the results of the logistic regression analysis for the prediction of failure of the PACU protocol. Univariate logistic regression analysis revealed child age (OR = 0.97/year), and renal dysfunction (OR = 0.6) andleft 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 Euro SCORE are also univariate predictors of the success of the PACU protocol. Multivariate logistic regression analysis revealed only child 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.

DISCUSSION

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. 60 patients (54.5%) fulfilled the criteria of the PACU protocol and were included in this study. 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 child 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 anesthesia without regional anesthetic techniques. In this regard, different combinations of anesthetic 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 anesthesia [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 25 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 morbid-ity 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 = 1 (1.7%)) were managed according to the PACU protocol because preopera-tive evaluation of the EF was subjectively performed using left ven-triculography. 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 proto-col. On the other hand, 1 patients (1.7%) 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 anesthesia 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. Precise preoperative 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 es-sential 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 man-datory 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]. Although lacking statistical significance, our data suggest that bleeding complications, signs of myocardial ischaemia, respira-tory 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 re-admission after CABG. For valve surgery, only preoperative congestive heart failure was an independent risk factor for fast-track surgery. 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 inde-pendent risk factors in predicting possible late discharge.

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 pre-dictors of failure of the protocol.

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