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A case-control study of readmission to the intensive care unit after cardiac surgery

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Background: The aim of this study was to identify predictors of repeated admission to the intensive care unit (ICU) of patients who underwent cardiac surgery procedures.

Material/Methods: This retrospective study analyzed 169 patients who underwent isolated coronary artery bypass grafting (CABG) between January 2009 and December 2010. The case group contained 54 patients who were readmitted to the ICU during the same hospitalization and the control group comprised 115 randomly selected patients.

Results: Logistic regression analysis revealed that independent predictors for readmission to the ICU after CABG were: older age of patients (odds ratio [OR] 1.04; CI 1.004–1.08); body mass index (BMI) >30 kg/m^2 (OR 2.55; CI 1.31–4.97); EuroSCORE II >3.9% (OR 3.56; CI 1.59–7.98); non-elective surgery (OR 2.85; CI 1.37–5.95); duration of operation >4 h (OR 3.44; CI 1.54–7.69); bypass time >103 min (OR 2.5; CI 1.37–4.57); mechanical ventilation >530 min (OR 3.98; CI 1.82–8.7); and postoperative central nervous system (CNS) disorders (OR 3.95; CI 1.44–10.85). The hospital mortality of patients who were readmitted to the ICU was significantly higher compared to the patients who did not require readmission (17% *vs.* 3.8%, p=0.025).

Conclusions: Identification of patients at risk of ICU readmission should focus on older patients, those who have higher BMI, who underwent non-elective surgery, whose operation time was more than 4 hours, and who have postoperative CNS disorders. Careful optimization of these high-risk patients and caution before discharging them from the ICU may help reduce the rate of ICU readmission, mortality, length of stay, and cost.

Key words: cardiac surgical procedures | complications | intensive care units | patient readmission

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Background

On average, 4–14% of patients discharged from intensive care units (ICUs) will be re-admitted [1–11]. It is known that re-admission to the (ICU) is often associated with increased in-hospital mortality, poor long-term prognosis, increased morbidity, and prolonged length of hospitalization, resulting in increased costs [1–3,8]. The increasing cost of ICU care and limited resources lead us to evaluate predictors of ICU readmission. In the present study we sought to determine predictors of ICU readmission in patients undergoing coronary artery bypass grafting (CABG) in our institution. The ability to predict who is at risk for ICU readmission may set the stage for pre-emptive strategies.

Material and Methods

We conducted a retrospective study of 169 patients who underwent isolated coronary artery bypass grafting (CABG) at our tertiary center between January 2009 and December 2010. The case group contained 54 patients who were readmitted to the ICU during the same hospitalization, and the control group comprised 115 randomly selected patients. Systematic sampling was used for selection of the control group. Median sternotomy was performed in all patients. Saphenous veins, the radial artery, and the internal mammary artery were used as conduits for myocardial revascularization. Myocardial protection during the aortic cross-clamping period was achieved with cold crystalloid cardioplegia. An anaesthesia technique using a combination of inhalation agents and opioids was used. After surgery, all the patients were directly admitted to the ICU.

Statistical analysis

Statistical analysis was performed using the SPSS 19.0 (Statistical Package for Social Science for Windows 19) statistical software package. Quantitative variables were described as mean and standard deviation (SD). The Kolmogorov-Smirnov test was used for determination of quantitative data distribution. When the distribution of variables was normal, Student's t test was used for comparison of quantitative sizes of 2 independent samples, and the non-parametric Mann-Whitney U test was used to compare non-normally distributed variables. Qualitative data was compared between the 2 groups using the chi-square (χ^2) test. Linear dependence between variables was evaluated using correlation coefficients. Pearson's or Spearman's correlation coefficient was used taking into account the distribution of variables. The difference was considered statistically significant when $p<0.05$. The probability of an event given certain risk factor was calculated using logistic regression analysis, including odds ratio (OR) and its confidence interval (95% CI).

Table 1. Reasons for readmission to the Intensive Care Unit.

Cause of readmission	Rate	
Arrhythmias	27	(50.0%)
Respiratory failure	16	(29.6%)
CPR	5	(9.3%)
Gastrointestinal abnormality	2	(3.7%)
Renal failure	2	(3.7%)
Hemodynamic instability	3	(5.6%)
Sepsis	1	(1.9%)
Not specified	7	(13.0%)

CPR – cardiopulmonary resuscitation.

Results

Out of 1045 adult patients who underwent CABG during the study period and who were discharged alive after the first ICU stay, 54 (5%) patients required readmission to the ICU during the same hospitalization. The most common cause for readmission was arrhythmias (mostly atrial fibrillation). Other causes are shown in Table 1. The mean interval from ICU discharge to repeated ICU admission was 4 days (range 1–47 days). The mean length of hospital stay was 21 days for patients not readmitted, and 37 days for those who were readmitted ($p<0.001$) to the ICU. The hospital mortality of patients readmitted to the ICU was significantly higher than patients who did not require readmission (17% *vs.* 3.8%, $p=0.025$).

There was no statistically significant difference between the mean length of the primary stay in the ICU of patients requiring readmission and non-readmitted patients (2.1±1.9 *vs.* 1.9±1.9 days, respectively).

Preoperative patient characteristics and perioperative variables were evaluated as predictors of ICU readmissions (Table 2). Analysis showed that older age of patients ($p=0.03$), body mass index (BMI) >30 kg/m^2 ($p=0.04$), non-elective surgery ($p=0.004$), duration of operation >4 h ($p=0.04$), bypass surgery time ($p=0.02$), and aortic cross-clamp time ($p=0.05$) were independent risk factors of readmission. Postoperative CNS disorders ($p=0.005$) and prolonged mechanical ventilation ($p=0.002$) appear to be the only independent postoperative predictors of readmission.

The logistic regression analysis revealed that independent predictors for readmission to the ICU after CABG were: age >70 years (odds ratio 2.86; CI 1.46–5.59), BMI >30 kg/m^2 (odds ratio 2.55; CI 1.31–4.97), EuroSCORE II >3.9% (odds ratio 3.56; CI 1.59–7.98), non-elective surgery (odds ratio 2.85; CI 1.37–5.95), duration of operation >4 h (odds ratio 3.44; CI 1.54–7.69),

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Table 2. Variable evaluated as predictors of Intensive Care Unit readmission.

Time	Characteristic	Control group (n=115) (SD)	Readmitted patients (n=54) (SD)	p-value
Preoperative	Mean age (years)	66.2 (9.4)	69.6 (8.1)	0.03
	Non–elective surgery (percent)	17	37	0.004
	Mean body mass index (kg/m^2)	28.8 (4.6)	30.4 (5.8)	0.04
	Smoking (percent) Yes No Former smokers	 14 81 5	 17 75 8	 ns
	Rhythm disorders (percent)	29	40	ns
	Conduction disorders (percent)	13	24	ns
	COPD (percent)	13	24	ns
	Diabetes mellitus (percent)	18	28	ns
	Renal failure (percent)	8	15	ns
	Preoperative β-blocker treatment (percent)	87	80	ns
	Ejection fraction mean, (percent)	47.0 (8.8)	48.0 (7.4)	ns
	EuroSCORE II mean, (percent)	8.9 (12.0)	11.4 (10.2)	0.009
Perioperative	Duration of operation, mean, (min)	209.0 (50.0)	223.0 (50.0)	0.04
	Bypass time, mean (min.)	98.1 (32.3)	109.3 (48.2)	0.02
	Aortic cross – clamp time, mean, (min)	49.0 (15.0)	54.4 (17.0)	0.05
Postoperative	Prolonged mechanical ventilation (h)	13.9 (18.9)	17.9 (21.0)	0.002
	Respiratory failure (percent)	16	28	ns
	Arrhythmias (percent)	18	30	ns
	Hemodynamic instability (percent)	13	9	ns
	Renal failure (percent)	3	4	ns
	CNS disorders (percent)	6	20	0.005
	Bleeding (percent)	7	3	ns
	Perioperative MI (percent)	3	6	ns
	Gastrointestinal abnormality	0	1	ns
	Length of stay, mean (day)	21.0 (18.0)	37.0 (36.0)	<0.001
	Mortality (percent)	6	17	0.025

CNS – central nervous system; COPD – Chronic Obstructive Pulmonary Disease; MI – myocardial infarction; ns – not significant; SD – standard deviation.

bypass time >103 min (odds ratio 2.5; CI 1.37–4.57), aortic cross-clamp time >46 min. (odds ratio 1.02; CI 1.0–1.04), mechanical ventilation >530 min (odds ratio 3.98; CI 1.82–8.7), postoperative central nervous system (CNS) disorders (odds ratio 3.95; CI 1.44–10.85) were (Table 3). Multivariate logistic regression analysis identified independent risk factors of readmission to ICU: age and prolonged mechanical ventilation (>825 min) after operation, bypass time >103 min, and mechanical ventilation >530 min (Tables 4 and 5).

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Table 3. Independent predictors of Intensive Care Unit readmission.

Variable	Odds ratio	Confidence interval
Age >70 years	2.86	1.46–5.59
Non-elective surgery	2.85	1.36–5.94
BMI >30 kg/m^2	2.55	1.31–4.97
EuroSCORE II >3.9%	3.56	1.59–7.98
Duration of operation >4 h	3.44	1.54–7.69
Bypass time >103 min	2.508	1.37–4.57
Aortic cross – clamp time >46 min	1.02	1.0–1.04
Mechanical ventilation >530 min	3.98	1.82–8.7
CNS disorders after operation	3.95	1.44–10.85

BMI – body mass index; CNS – central nervous system.

Discussion

The rate of ICU readmission in our study was 5%. This ICU readmission rate appears similar to that of other reported studies, which have ranged from 4% to 14% [1–11]. Readmission to the ICU is known to be an indicator of poor prognosis. Our results support this conclusion by demonstrating that the in-hospital mortality and hospital stay were significantly higher for patients readmitted to the ICU. Readmission rates have been associated with premature discharges in several studies [9,12–14], but in our study the mean length of the primary stay in the ICU of patients requiring readmission and patients who had no readmission to the ICU were not statistically significantly different – 5.7 (9.5) and 4.4 (7.1) days, respectively. Furthermore, discharge after less than a 24-hour initial stay in the ICU was not a risk factor of readmission (p=0.08). The independent predictors of readmission in our study were older age, higher BMI (>30 kg/m^2), non-elective surgery, longer operation time (>4 h) and aortic cross – clamp time, postoperative CNS dysfunction, and prolonged lung ventilation.

Older age is a risk factor associated not only with readmission to the ICU; it also correlates with increased mortality and morbidity following cardiac surgery [15]. As the population gets older, the average age of patients undergoing surgery also increases. This is associated with the influence of age-related changes affecting different organ systems, and comorbidities that are more prevalent among elderly patients. Given this, it is appropriate to analyze the perioperative course features in elderly patients and to improve their care [16]. Emergency non-elective surgery is another risk factor, mentioned in other studies, with cardiac surgery being no exception [3,4,15]. Emergency surgery and older age predispose patients to both

Table 4. Multivariate logistic regression analysis age and prolonged mechanical ventilation as risk factors of readmission to Intensive Care Unit.

Variables		Odds ratio [confidence interval]
Age, years	<70	1
	>70	3.539 [1.785–7.016]
Prolonged mechanical ventilation (min.)	>825	1
	<825	4.141 [1.991–8.612]
Constant =–1.161		

Table 5. Multivariate logistic regression analysis bypass time and mechanical ventilation as risk factors of readmission to Intensive Care Unit.

Variables		Odds ratio [confidence interval]
Bypass time, (min)	<103	1
	>103	2.122 [1.054–4.271]
Prolonged mechanical ventilation, (min)	<530	1
	>530	3.574 [1.616–7.908]
Constant =–1.953		

ICU readmission and higher overall morbidity and mortality. Operation time, cardiopulmonary bypass time, and aortic cross-clamping period correlate with each other and are risk factors for re-admission to the ICU. Al-Sarraf et al have shown that prolonged duration of aortic cross-clamping has a negative effect on outcome, increasing post-operative morbidity and mortality in both low- and high-risk patients [17]. Other authors have observed that a longer aortic cross-clamp time worsens outcomes in patients with preserved ejection fraction (40% or higher) [18]. Low BMI (<21 kg/m^2) and high BMI (>30 kg/m^2) are both risk factors associated with adverse outcomes after cardiac surgery [15,19]. In our study, only 2 (2.1%) patients had BMI <21 kg/m^2. A BMI above 30 kg/m^2 was observed in 66 (39%) patients, and statistical analysis showed that BMI greater than 30 kg/m^2 is a risk factor for ICU readmission.

The occurrence of CNS disorders after surgery was the only independent post-operative risk factor of readmission. The incidence of CNS dysfunction is higher after cardiac than non-cardiac surgery, and the risk increases with age [20]. Four neurologic and cognitive complications are observed after cardiopulmonary bypass (CPB): stroke (with an incidence of 1.5% to 5.2%), postoperative delirium (10% to 30%), short-term (33% to 83%), and long-term cognitive changes (20% to 60%). CNS disorders are associated with many negative consequences.

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Preventive interventions and early recognition of those patients could potentially decrease CNS disorders and their negative consequences.

The main cause of ICU readmission was cardiac arrhythmias (for the most part atrial fibrillation) (50%). ICU readmission was due to respiratory failure in 30% of cases. Atrial fibrillation (AF) and atrial flutter occur frequently after most types of cardiac surgery. AF has been reported in 15% to 40% of patients in the early postoperative period following CABG, in 37% to 50% after valve surgery, and in as many as 60% undergoing valve replacement plus CABG [21,22].

A multicenter study on AF after cardiac surgery has shown that post-operative AF is associated with prolonged hospital stay, higher incidence of infections, renal failure, and neurological complications. Other risk factors include advanced age, and postoperative withdrawal of a beta-blocker or an angiotensin-converting enzyme (ACE) inhibitor. Reduced risk was associated with postoperative administration of beta-blockers, ACE inhibitors, potassium supplementation, and nonsteroidal anti-inflammatory drugs [21,22].

Conclusions

Identification of older patients, those who have higher BMI, who underwent non-elective surgery, who experienced surgery lasting more than 4 hours, and who have postoperative CNS disorders, may help to identify patients at risk of ICU readmission. Careful optimization of these high-risk patients and caution before discharging them from the ICU may help reduce the rate of ICU readmission, mortality, length of stay, and cost.

Conflicts of interest

None of the authors have any conflicts of interest pertaining to this article.

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