

## ICU readmission after cardiac surgery

T. Bardell, J.F. Legare, K.J. Buth, G.M. Hirsch, I.S. Ali\*

*Division of Cardiac Surgery, New Halifax Infirmary, Halifax, Nova Scotia, Canada*

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### Abstract

**Objectives:** The increasing cost of intensive care unit (ICU) care and limited resources lead us to evaluate predictors of ICU readmission in a large group of patients undergoing coronary artery bypass surgery (CABG) at one institution. **Methods:** Two thousand one hundred and seventeen consecutive patients undergoing CABG surgery between January 1999 and August 2001 were reviewed retrospectively. The reasons for readmission were determined by reviewing the physician's progress notes, the nurse's progress notes and the discharge summary. **Results:** A total of 75 patients were readmitted to ICU during the study period for a readmission rate of 3.6%. Eight of these were readmitted a second time, and three a third time, for a total of 86 readmissions. Forty-seven patients died, for a mortality of 2% among patients that were not readmitted to the ICU, compared to 17% among those who were readmitted ( $P < 0.0001$ ). Median hospital length of stay was 6 days for patients not readmitted and 23 days for those readmitted ( $P < 0.0001$ ). The most common reason for readmission was respiratory failure, accounting for 47% of readmissions ( $n = 40$ ). Multivariate analysis using a stepwise logistic regression analysis revealed that preoperative renal failure (odds ratio 2.13; CI 1.03–4.41) and prolonged mechanical ventilation of  $>24$  h (odds ratio 10.52; CI 6.18–17.91) were the only independent predictors for readmission to the ICU after CABG. **Conclusions:** Identification of patients that have preoperative renal failure or that required initial ventilation for more than 24 h after CABG may help to identify patients at risk of ICU readmission. Preemptive strategies designed to optimize these high-risk patients may improve outcomes.

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### 1. Introduction

Intensive care is a standard component of postoperative treatment for most patients who undergo cardiac surgery. However, a prolonged intensive care unit (ICU) stay is often associated with increased in-hospital mortality, poor long-term prognosis, increased morbidity [2–4], and prolonged length of hospitalization resulting in increased costs [5,6]. Knowledge of this relationship has stimulated interest in reducing the length of ICU stay [1] by methods such as standardized fast-tracking and early extubation programs following routine cardiac surgical procedures [7–9]. However, concern that these early discharges may result in an increase in the rate of ICU readmission has been expressed [10].

ICU readmission is believed to be associated with higher in-hospital mortality and may predict poor outcomes [11]. Only a few studies have considered the issue of readmission

to the ICU in surgical patients [12–14]. These have produced variable results because of the heterogeneity of patients evaluated, presumably related to the varied nature of the operations typically performed at the respective institutions. Taken together, the most reliable predictor of readmission reported by these studies was unstable vital signs at the time of ICU discharge [11].

We are aware of only one study that examined cardiac surgery patients specifically [10]. In that study, Cohn et al. found an increase in cardiac surgery ICU readmissions over a 4 year time frame. Their study was motivated by a concern that the increase in ICU readmissions may have resulted from an observed decrease in initial ICU length of stay during the same period. Instead they found that patients discharged earlier from the ICU generally were not readmitted as often as those who had prolonged initial ICU stays. This begs the questions, why was their rate of ICU readmission increasing, and if ICU readmissions are not a result of shorter initial ICU stays, what are the causes?

In the present study we sought to determine predictors of ICU readmission in a large group of patients undergoing coronary artery bypass surgery (CABG) at a single institution, and to evaluate their longitudinal follow-up in terms of

\* Corresponding author. New Halifax Infirmary, QEII HSC, Division of Cardiac Surgery, 1796 Summer Rm. 2269, Halifax, Nova Scotia, B3H 3A7, Canada. Tel.: +1-902-473-7597; fax: +1-902-473-4448.

E-mail address: imtiaz.ali@dal.ca (I.S. Ali).

mortality over time. The ability to predict who is at risk for ICU readmission may set the stage for preemptive strategies.

## 2. Methods

### 2.1. Patients

Two thousand one hundred and seventeen consecutive patients undergoing isolated CABG at a single university affiliated institution between January 1999 and August 2001 were reviewed retrospectively. The decision to proceed with surgery was based on a weekly peer review process involving cardiologists, cardiac surgeons and cardiac radiologists such that individual patients were waitlisted according to the urgency of the procedure. Cardiopulmonary bypass (CPB) was performed in a standardized fashion. Body temperature during the procedure was allowed to drift to approximately 32 °C. Standard cardioplegia used was intermittent cold blood delivered antegrade unless otherwise indicated.

### 2.2. Data collection

Perioperative patient variables were collected on Society of Thoracic Surgeons (STS) forms by three full time research assistants and maintained in a computer database format (Summit Medical Systems, Inc. MN, USA, 1997). This has been standard practice at this institution for all cardiac surgical cases since 1995 with data element validation. Urgency status was also determined using the standard STS Cardiac Surgery Database definitions. An elective case was defined as one in which the patient was stable for more than 24 h prior to the procedure. Urgent operations were

those that required a procedure to be performed within 24 h to prevent further clinical deterioration, and emergent/salvage cases were those patients who required an immediate operation. The variables evaluated included: age, chronic obstructive pulmonary diseases (COPD), cross-clamp time, diabetes, ejection fraction (EF), gender, hypertension, intra-aortic balloon counter-pulsation use, New York Heart Association class (NYHA), perioperative myocardial infarction (MI), preoperative hospitalization, preoperative renal failure (renal failure was defined as a serum creatinine greater or equal to 177 mmol/l), prolonged ventilation, pump time, reoperation, stroke, and urgency status.

### 2.3. Clinical decision making

All postoperative cardiac surgery patients were taken to a dedicated cardiovascular intensive care unit (CVICU), not a post-anesthesia recovery care unit. The decision to discharge patients from the ICU was made on an individual, patient-by-patient basis by one of the seven attending cardiovascular surgeons, two cardiac anesthetists, and/or supporting resident house-staff taking care of the patient. Patients were generally not transferred from the ICU if they were considered at risk clinically for decreased oxygen delivery. This included patients with signs of inadequate tissue perfusion (lactate levels >4 mmol/l, mixed venous oxygen saturation <50%, urine output <0.5 ml/kg per h, cardiac index <2 l/min per m<sup>2</sup>), significant hemodynamic instability, patients requiring inotropes other than low dose dopamine (<3 µg/kg per min), utilization of an intra-aortic balloon pump (IABP) or a ventricular assist device (VAD), and patients with multi-organ dysfunction.

Table 1  
Univariate predictors of ICU readmission

Time	Characteristic	Control (n (%))	Readmitted patients (n (%))	P value	
Preoperative	Age >70	670 (33)	33 (44)	0.04	
	Female gender	500 (25)	16 (21)	0.53	
	Renal failure	92 (5)	12 (16)	<0.0001	
	Chronic obstructive pulmonary disease	320 (16)	22 (29)	0.002	
	New York Heart Association class IV	961 (47)	51 (68)	0.0004	
	Diabetes	726 (36)	32 (43)	0.21	
	Hypertension	1304 (64)	51 (68)	0.46	
	Ejection fraction <40	236 (12)	16 (22)	0.009	
	Urgent	267 (13)	14 (19)	0.3	
	Redo operation	99 (5)	8 (11)	0.02	
	Preop hospitalization	914 (45)	47 (63)	0.002	
	Triple vessel disease	1587 (78)	65 (87)	0.2	
	Postoperative	Reintervention	119 (6)	38 (51)	<0.0001
		Perioperative myocardial infarction	32 (2)	2 (3)	0.45
Stroke		43 (2)	6 (8)	0.0009	
Prolonged ventilation		208 (10)	45 (60)	<0.0001	
Length of stay (mean)		6 + 10	23 + 27	<0.0001	
Mortality		47 (2)	13 (17)	<0.0001	

Discharged patients were transferred to an intermediate care or general care ward under the care of the same surgeons and house-staff team. Patients readmitted to the ICU were identified by reviewing the ICU logbook. Note that a few patients were readmitted to a medical ICU when no beds were available in CVICU and were considered readmissions in this study. The reasons for readmission were determined by reviewing the physician's progress notes, the nurse's progress notes and the discharge summary.

#### 2.4. Statistics

Descriptive statistics were obtained for all variables using the SAS software package (SAS, Version release 6.12, SAS Institute Inc., Cary, NC). These included continuous and discrete variables which were analyzed with Student's *t*-test, the chi-squared test, or Fisher's exact test where appropriate. A stepwise logistic regression model was developed to identify predictors of ICU readmission for patients undergoing CABG. Univariate predictors of ICU readmission were entered into the model if the *P* value was less than or equal to 0.05. Kaplan–Meier survival analysis was used to evaluate all cause mortality. Mortality data were obtained from vital statistics (Government of Nova Scotia), by contacting the family physicians of the individual patients to obtain the last known follow-up, and by attempting to contact the patients directly.

### 3. Results

#### 3.1. Patient characteristics

A total of 2117 consecutive patients undergoing CABG were included in this study. The mean age of all patients was  $65 \pm 11$  years with 33% of patients aged more than 70. Seventy percent of patients were male, 36% were diabetic and 12% had an EF of less than 40%. Ninety percent of patients were in NYHA class III or IV at the time of surgery. Complete preoperative patient demographics are illustrated in Table 1.

#### 3.2. Readmission to ICU

A total of 75 readmitted patients were identified, yielding an ICU readmission rate of 3.6%. Eight of these patients were readmitted on two occasions, and two on three occasions. The readmission rate during the study period was relatively constant. Patients were readmitted to the ICU when their clinical condition deteriorated on the ward and required an intervention such as inotropic support (other than low dose dopamine), invasive monitoring, dialysis, or mechanical ventilation, which are not possible in an intermediate care unit setting. The most common reason for readmission was respiratory failure, accounting for 47% of the patients ( $n = 40/86$ ). In the majority of these patients no clear etiology could be identified other than increased

respiratory distress and/or difficulty clearing secretions ( $n = 29$ ). Twenty percent of patients ( $n = 17/86$ ) were readmitted for cardiac reasons. A complete summary of reasons for readmission is given in Table 2.

#### 3.3. Patient outcomes

The overall mortality rate was 2.8% for all patients included in this study ( $n = 60/2117$ ). However, patients readmitted to ICU had a mortality rate of 17% ( $n = 13/75$ ;  $P < 0.0001$ ). Of the 13 readmitted patients who died, four died of the same cause that brought them back to the ICU (two cardiac, two sepsis). The other nine patients died for different reasons than were identified as the reason for readmission (Table 3). A Kaplan–Meier curve showing survival for patients readmitted to the ICU is shown in Fig. 1. Mortality follow-up was obtained for 73 of the 75 patients readmitted to the ICU. Of these, 13 died in hospital and six more died within the first year. There were no deaths recorded between 1 and 3 years post-operation with 23 patients at risk after 12 months.

Median length of hospitalization was  $6 \pm 10$  days for patients not readmitted and  $23 \pm 27$  days for those readmitted ( $P < 0.0001$ ). The median initial ICU stay prior to discharge in patients that were eventually readmitted was  $6 \pm 8.7$  days as compared to a median of 1 day in patients

Table 2  
Reasons for readmission to the ICU

Cause	Sub-classification	<i>n</i> (%)
Respiratory	Total	40 (47)
	No clear etiology or difficulty clearing secretions	29
	Pneumothorax	2
	Aspiration	1
	Exacerbation of COPD	2
	Marked atelectasis	1
	Pulmonary embolism	1
	Pleural effusion	2
	Hemothorax	1
	Fluid overload	1
	Cardiac	Total
Cardiac arrest		8
Arrhythmia		3
Angina		3
CHF		1
Tamponade		1
Hypotension		1
Sepsis <sup>a</sup>		12 (14)
Gastrointestinal (GI) <sup>b</sup>	9 (10)	
Sternal dehiscence, no infection	3 (3)	
Renal	1 (1)	
Stroke	2 (2)	
Pericardial clot	1 (1)	
Glycemic control	1 (1)	
Total	86 (99)	

<sup>a</sup> Seven originated from a sternal wound infection.

<sup>b</sup> GI bleed ( $n = 3$ ) and perforation ( $n = 6$ ).

Table 3  
Mortality among patients readmitted to the ICU

Case	Cause of readmission	Cause of death	Time from operation to death (days)
1	Sepsis	GI <sup>a</sup>	46
2	Respiratory	Sepsis	66
3	Respiratory	Cardiac	137
4	Angina	Cardiac	5
5	GI bleed	Respiratory	88
6	Sepsis	Sepsis	73
7	Respiratory	Sepsis	25
8	Respiratory	Cardiac	18
9	Respiratory	CVA <sup>b</sup>	109
10	Cardiac arrest	Cardiac	24
11	Sepsis from sternotomy infection	Cardiac	88
12	Sepsis from sternotomy infection	Sepsis	33
13	Pleural effusion	GI	16

<sup>a</sup> GI, Gastrointestinal.

<sup>b</sup> CVA, cerebrovascular accident.

not requiring readmission. Once discharged from ICU the time elapsed before readmission is illustrated in Fig. 2, which demonstrates that one-third of readmissions occurred within 24 h of discharge.

3.4. Logistic regression analysis

Preoperative patient characteristics and perioperative variables were evaluated as predictors of ICU readmission. Significant univariate predictors of ICU readmission were found to be: COPD, renal failure, age >70, NYHA IV, redo surgery, low EF, longer preoperative hospitalization, prolonged mechanical ventilation, and permanent stroke (Table 1). Gender, diabetes, hypertension, urgency status, IABP use, cross-clamp time >90 min, pump time >120 min, and perioperative MI were not predictive of readmission to the ICU. Multivariate analysis using a stepwise logistic regression analysis revealed that preoperative renal failure (odds ratio 2.13; CI 1.03–4.41) and prolonged ventilation (odds ratio 10.52; CI 6.18–17.91) were the only independent predictors for readmission to the ICU after

Time before ICU readmission

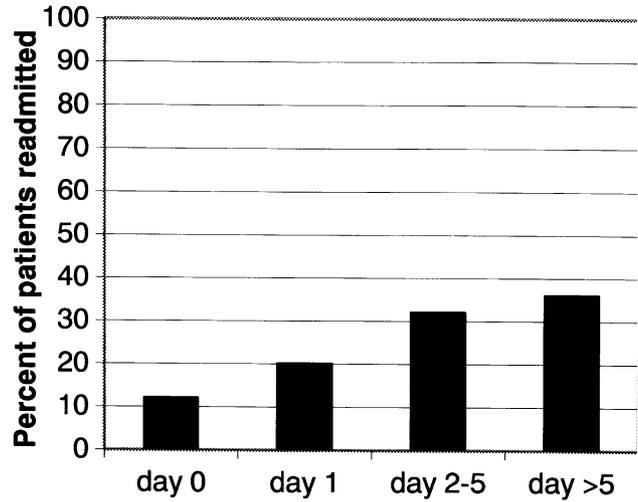


Fig. 2. Percentage of readmitted patients returning to the ICU on post-operative days 0, 1, and 2–5, and after postoperative day 5.

CABG (Table 4). The *c* statistic for the model was 0.786 with a Hosmer and Lemeshow goodness-of-fit test of 0.751.

4. Discussion

The rate of readmission to ICU in the present series of 2117 consecutive patients who underwent CABG was 3.7%. This ICU readmission rate appears similar to other reported series, which have ranged from 4.6% to 5.5% [10,14]. Readmission to the ICU is known to be an indicator of poor prognosis [11–13]. Our results support this conclusion by demonstrating that the risks of stroke, reoperation, prolonged mechanical ventilation, and prolonged hospitalization were all significantly higher for patients readmitted to the ICU. Pulmonary and cardiac complications were the most common reasons for readmission, a finding that has been reported across several patient populations [10,12,14,15]. Furthermore, those patients that are readmitted are at greater risk of in-hospital mortality (17%). Short-term follow-up of patients by Kaplan–Meier analysis suggests that ICU-readmitted patients who are eventually discharged from hospital may do reasonably well with a 1 and 3 year freedom from death of 68%. However, this analysis was limited by small numbers (*n* = 75 events) with only 23 patients followed beyond 1 year.

Cohn et al. [10] attempted to predict a return to ICU by identifying several clinical variables related to ICU read-

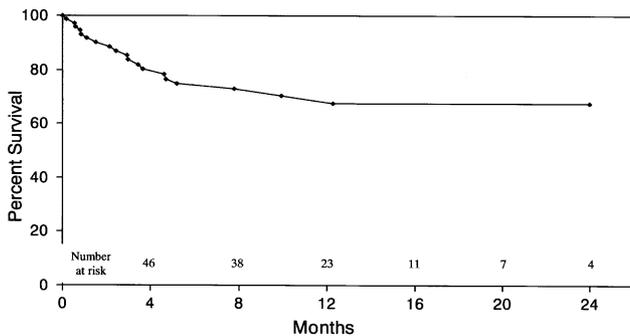


Fig. 1. Kaplan–Meier curve showing survival as a function of time for patients readmitted to the ICU.

Table 4  
Multivariate predictors of ICU readmission

Variable	Odds ratio	Confidence interval
Renal failure	2.13	1.03–4.41
Prolonged ventilation	10.52	6.18–17.91

mission which included: longer initial ICU length of stay, poor left ventricle (LV) function, a history of congestive heart failure (CHF), longer initial intubation time, and post-operative weight gain. Similarly, we found COPD, renal failure, age >70, NYHA IV, redo surgery, low EF, prolonged initial mechanical ventilation and longer preoperative hospitalization all to be univariate predictors of ICU readmission. However, only preoperative renal failure and prolonged mechanical ventilation were shown to be independent predictors of readmission to ICU after multivariate analysis.

Both of these multivariate predictors of ICU readmission fit well with our understanding of perioperative morbidity. Patients with renal failure are at greater risk of complications related to poor nutrition, fluid overload and respiratory dysfunction, metabolic and electrolyte abnormalities, and problems of drug overdose and toxicities, all of which can necessitate a return to the ICU. Preoperative renal failure and the need for postoperative dialysis have both been associated with increased perioperative mortality [16]. While prolonged mechanical ventilation defined as greater than 24 h is required in less than 10% of patients who undergo CABG surgery [4], it was shown in the present study to be the strongest predictor of a return to ICU with an odds ratio of 10. Prolonged ventilation is a surrogate for poor outcome and is known to be associated with several important variables including preoperative low EF, renal failure, COPD, age, gender, and unstable angina [4]. Despite the inherent limitations of a retrospective study we have identified two important clinical variables that appear to predict a return to ICU and on which adjustments to patient care can be focused.

There is considerable debate regarding how information on ICU readmission rates can best be used. It may be that centers with high rates of readmission are delivering substandard care. Alternatively, these centers may be more aggressive with respect to early discharge from ICU in an attempt to reduce costs. While patients readmitted to the ICU have a worse course in general, there is no evidence that patients readmitted to the ICU would have had a better outcome had the event that brought them back to the ICU occurred in the ICU rather than on the wards [17]. Furthermore, the role of intensive care itself may be in question. ICU practice patterns vary widely, with one study estimating ICU utilization in the United States to be 2.5 times that in Canada [18]. What is well established is that those who return to the ICU fair worse, making the prediction of this event worthwhile. In clinical practice, attention should be paid to optimizing the recovery of patients that have undergone prolonged ventilation or those in renal failure before discharging them from the ICU. Further research into methods of avoiding these complications may help to decrease the rate of ICU recidivism.

Considerable effort has been invested in reducing the length of hospital stays using fast-tracking protocols in an attempt to reduce cost [19]. It would appear that discharging

patients earlier from the ICU does not affect the rate of readmission [10]. In fact more than two-thirds of patients readmitted to ICU in the present study had been discharged for 2 or more days suggesting that too early an original discharge was not likely the cause for readmission. The economic impact of discharge and readmission to the ICU versus remaining in the ICU has not been determined. It has been suggested that the former may be more costly, as the greatest proportion of ICU costs are accrued on the first day, and presumably a readmission to the ICU would be like a second 'first day' [20]. This may not be true in other institutions within different healthcare systems. One method that has been proposed to reduce readmission rates to ICUs is to include the appointment of a follow-up nurse [21].

In summary, identification of patients that have preoperative renal failure or that have undergone ventilation for more than 24 h after CABG 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 to reduce the rate of ICU readmission, with a possible decrease in mortality, length of stay, and cost.

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