European Journal of Cardio-thoracic Surgery 22 (2002) 282–286

EUROPEAN JOURNAL OF CARDIO-THORACIC SURGERY

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A case-control analysis of readmissions to the cardiac surgical intensive care unit

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Received 11 December 2001; received in revised form 16 May 2002; accepted 20 May 2002

Abstract

Objective: To identify predictors of requirement for readmission to the intensive care unit (ICU) for patients undergoing cardiac surgery. **Methods**: The setting was a 17-bedded ICU in a tertiary level institute for specialist adult cardiorespiratory disease. The case notes and ICU charts of 65 ICU readmissions and 65 controls, matched for day of initial ICU discharge, were analysed. Patient variables assessed included preoperative risk stratification, ICU admission APACHE III score and intensive therapy interventions, complications and indication for readmission if readmitted. **Results**: Twenty of 65 patients (31%) readmitted to the cardiac ICU died, compared with no mortality among the control group. Significant univariate determinants of ICU readmission (odds ratio, 95% confidence interval) included worse angina (1.38, 0.99–1.91) and dyspnoea (1.70, 1.10–2.61) classes and corresponding non-elective surgery (2.04, 1.31–3.19), higher Parsonnet score (1.06, 1.01–1.11) or EuroSCORE (1.14, 1.01–1.28), APACHE III score (1.03, 1.00–1.05), body mass index > 27 (4.25, 1.43–12.63), non-usage of beta-blockers (1.53, 1.03–2.26), emergency resternotomy (5.00, 1.10–22.79), and lower haemoglobin (0.75, 0.58–0.96), higher required inspiratory oxygen (1.05, 1.02–1.08), and higher respiratory rate upon ICU discharge (1.09, 1.01–1.18). Renal failure, respiratory failure and cardiac arrest were the most common indications for ICU readmission. Thirty-five of 65 patients readmitted to the ICU required ventilation for a mean of 7.1 days. The mean ICU readmission duration for all 65 cases was 5.7 days. **Conclusions**: Readmission of cardiac surgical patients to the ICU is associated with high morbidity and mortality, and substantial resource consumption. Parsonnet or EuroSCORE risk stratification models in combination with obesity, operative urgency, resternotomy and respiratory indices at time of intended ICU discharge are strongly associated with readmission to ICU.

Keywords: EuroSCORE; Intensive care unit readmission; Risk stratification

1. Introduction

Staffed intensive care unit (ICU) beds are at a premium. The return of patients to the ICU is yet another cause of staffed intensive care bed shortages, dealing a financial blow to the throughput of the cardiac surgical service. It also impacts adversely on patients awaiting their operation. Furthermore, the mortality rate among those readmitted is appreciably high [1,2]. The discharging physician's judgement is constantly put to the test as he/she is called upon to rationalize a scarce resource [3,4]. Intensive care decision-making needs to be guided by quantitative data and risk probabilities [5]. The question of an intermediate care unit as a step-down to the general ward also needs to be addressed [6]. A retrospective study of the readmissions to our cardiac surgical intensive care unit, compared to a case controlled group of patients, was undertaken in an attempt to profile these patients with regards to risk stratification and treatment dependence and outcomes.

2. Materials and methods

Papworth Hospital (Cambridge, UK) is a specialist tertiary health care institute for adult cardiopulmonary disease, and performs around 1800 general cardiac and 80 cardiac transplantation operations annually. During the time period of this study, it was outfitted with a 17-bedded ICU with primary dedication to surgical cases, but no high dependency unit.

The study was of a matched case control design. All adult general (non-transplant) cardiac surgical patients who were admitted to the ICU over the time period January 1, 1998 to December 31, 1998 inclusive, and who subsequently required readmission within a single hospitalization were

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1010-7940/02/$ - see front matter
PII: S1010-7940(02)00303-2

Table 1
Univariate odds ratios for significant variables in exploratory analysis[a]

Variable	Odds ratio (95% CI)	LR Statistic ($\chi^2(1)$), significance
NYHA per class	1.70 (1.10–2.61)	6.34, $P = 0.012$
CCS per class	1.38 (0.99–1.91)	3.91, $P = 0.048$
Parsonnet score per point	1.06 (1.01–1.11)	7.05, $P = 0.008$
EuroSCORE per point	1.14 (1.01–1.28)	5.30, $P = 0.021$
24 h APACHE score per point	1.03 (1.00–1.05)	4.96, $P = 0.026$
Discharge APACHE score per point	1.03 (1.00–1.05)	3.81, $P = 0.051$
Non-elective surgery	2.04 (1.31–3.19)	12.51, $P < 0.001$
Body mass index per kg/m^2	1.14 (1.02–1.27)	5.88, $P = 0.015$
Body mass index > 27	4.25 (1.43–12.63)	8.66, $P = 0.003$
Beta-blockers	1.53 (1.03–2.26)	4.94, $P = 0.026$
Resternotomy for any reason	5.00 (1.10–22.79)	5.82, $P = 0.016$
ICU discharge haemoglobin per g/dl	0.75 (0.58–0.96)	6.02, $P = 0.014$
ICU discharge FiO_2 per %	1.05 (1.02–1.08)	13.35, $P < 0.001$
Respiratory rate per breaths/min	1.09 (1.01–1.18)	5.44, $P = 0.020$
Urea at initial ICU discharge	1.07 (0.98–1.18)	2.84, $P = 0.092$

[a] CI, confidence interval; LR, logistic regression.

identified from hospital admissions databases and clinical records were studied. Of the 71 patients identified, six were excluded because the first admission had taken place preoperatively. The remaining 65 made up the cases of readmission to ICU. For each case a control was selected from the hospital admissions database on the basis of no return to ICU in the same admission, and being the nearest age–sex match discharged from ICU on the same day as the case was first discharged from ICU.

A range of potential risk factors for readmission to ICU were considered including preoperative comorbidity, operative factors, and cardiac, pulmonary and renal function on the initial admission to the ICU. Risk scores were also applied using both Parsonnet [7] and EuroSCORE [8] systems. APACHE III scores [9] for three key times were derived from examination of the patients' intensive care charts and notes: (1) the first 24 h or part thereof in the ICU, (2) at initial discharge from the ICU, and (3) the first 24 h following readmission to the ICU.

2.1. Statistical analysis

Data collection was carried out using Microsoft Excel 2000 spreadsheet. Statistical analysis was carried out using the statistical software package S-Plus (MathSoft, Seattle, WA, USA). Associations between risk factors and return to ICU were assessed using conditional logistic regression and odds ratios of readmission to ICU calculated. The matched case-control design was also taken into account to produce more accurate estimates of the associations. Initially, all important factors were assessed in univariate models and statistical significance ($P < 0.05$) was determined by the likelihood ratio test.

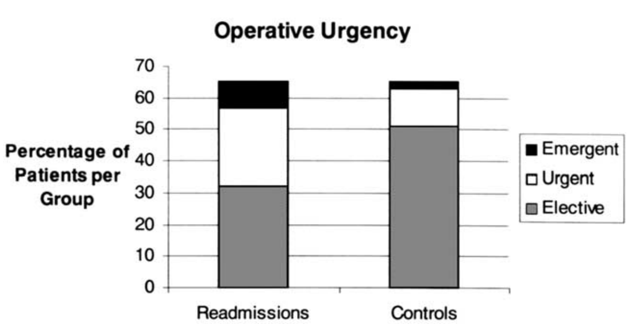

Fig. 1. Distribution of surgical urgency.

3. Results

Of the 1745 adult patients who underwent general (non-transplant) cardiac operations during the study period, 65 had at least two postoperative admissions to the ICU during the same hospitalization. Case controls were selected from a total of 390 potential candidates matched for date of initial ICU discharge.

Case and control groups did not differ significantly in age (67.4 years versus 66 years, respectively) or sex ratio (67.7 versus 72.3% male, respectively). The most significant characteristics analysed for ICU readmission prediction are listed in Table 1. Symptom severity and correspondingly operative urgency were both statistically significant. 52.3 and 44.6% of readmission cases were CCS class III or IV and NYHA class III or IV, respectively, compared with only 26.2 and 27.7%, respectively, of control patients. The distribution of surgical urgency is shown in Fig. 1. Both Parsonnet and EuroSCORE risk stratification systems were found to be statistically significant univariate predictors of ICU readmission. The admission APACHE III score was also significant but the ICU discharge APACHE III score just failed to reach statistical significance (mean control APACHE III 57.4 versus mean readmission APACHE III 63.3, $P = 0.051$). Non-elective urgency of surgery ($P < 0.001$) and higher required inspiratory oxygen upon

Table 2
Predictive model for risk of readmission to the ICU

Variable	Odds ratio (95% CI)	LR Statistic ($\chi^2(1)$), significance
Parsonnet score per point	1.13 (0.99–1.29)	5.84, $P = 0.016$
Non-elective surgery	2.13 (0.90–5.03)	12.51, $P < 0.001$
Body mass index > 27	7.20 (0.94–55.28)	3.76, $P = 0.052$
FiO_2 per%	1.09 (1.02–1.17)	7.99, $P = 0.005$
Respiratory rate per breaths/min	1.30 (1.01–1.66)	4.13, $P = 0.042$

discharge ($P < 0.001$) were the strongest predictors for readmission.

Multivariate models for relative risk of ICU readmission were developed using either cardiac surgical risk stratification system. While Parsonnet score remained significant in the final model ($P = 0.016$), EuroSCORE did not ($P = 0.058$) (Table 2).

The mean number of days elapsed from initial ICU discharge to ICU readmission was 5.2 days (range < 12 h to 24 days), with eight patients being readmitted within 12 h. The indications for ICU readmission are listed in Table 3. The most common indication was renal failure (16 patients) followed by respiratory failure (15 patients) and cardiac arrest (14 patients). The mean APACHE III score (derived from 59 patients) on readmission was 66.6. Two patients underwent a second cardiac operation while four had a laparotomy. Seven readmission patients had undergone sternal debridement for mediastinal sepsis.

Thirty-three readmissions required reventilation, of whom 15 were ventilated for more than 24 h, three ultimately needing a tracheostomy. Five patients were haemofiltered and eight were electrically cardioverted for haemodynamically compromising arrhythmias.

Complications developing during the second admission to the ICU are shown in Fig. 2. Cardiac arrest and pneumonia were the most common, occurring in seven patients each. Eight patients who were discharged from the ICU a second time were further readmitted for at least a second time. The mortality among readmissions was 30.8%. There was no mortality among the control group.

Table 3
Indications for ICU readmission (not mutually exclusive)

Cardiac arrest	14 (21.54%)
Shock (without cardiac arrest)	5 (7.69%))
Pulmonary oedema	4 (6.15%)
Pulmonary embolism	4 (6.15%)
Respiratory failure	15 (23.08%)
Renal failure	16 (24.62%)
Septicaemia	2 (3.08%)
Rewiring	7 (10.77%)
GI complication	5 (7.69%)
Myocardial infarction	1 (1.54%)
Dysrhythmia	12 (18.46%)
Neurological event	7 (10.77%)
Other	2 (3.08%)

4. Discussion

ICU readmission and its resultant extended ICU stay have several adverse sequelae, from futile consumption of valuable resources [10–13] and prolonged hospital length of stay, to increased mortality and poor quality of life following discharge [14]. In a setting of cardiac surgery, ICU readmissions comprise a group contributing to significant yet poorly defined morbidity and mortality. A retrospective study of the readmissions to our cardiac surgical intensive care unit, as compared to a case-controlled group of patients, was undertaken in an attempt to profile these patients with regards to risk stratification, treatment dependence and outcomes.

Patient profiling of cardiac surgical readmissions is lacking, and only few studies have been undertaken to examine patients readmitted to general medical and surgical ICUs. Indeed, major ICU severity scoring systems abjectly avoid including this group of patients in their profile analysis [6,15,16]. The prediction of outcomes of cardiac surgical patients has remained elusive [17]. Our study identified worse angina and dyspnoea severity, impaired left ventricular function, operative urgency, and case complexity (endocarditis and aortic surgery) as significant preoperative characteristics for ICU readmission. Postoperatively, cardiovascular support, ventilation beyond 24 h and ICU complications (particularly resternotomy) were significant.

The readmission rate to general medical and surgical ICUs has been quoted at 4.6–12% [1,2,18–21]. In the general ICU, recurrence or persistence of the original condition is the usual cause for ICU readmission [1,18]. Pulmonary failure and general sepsis are also major causes of ICU readmission

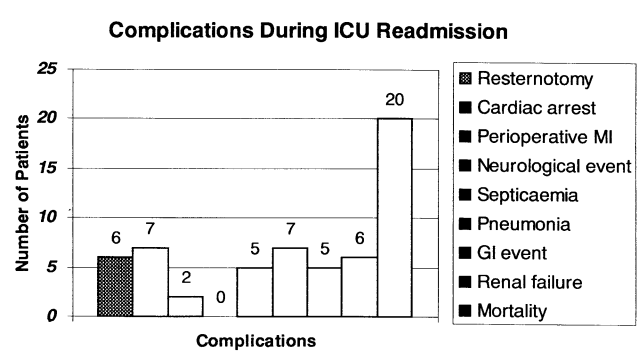

Fig. 2. Complications of patients readmitted to ICU.

[1,2,18]. In our adult general cardiac surgical ICU, acute renal failure, pulmonary failure and cardiac arrest were the main contributors to the readmission rate of 3.7%.

The 30.8% mortality rate amongst readmissions in our unit is over-represented compared with the control group since 14 of the patients were resuscitated from sudden death and transferred emergently to the ICU. This, nevertheless, is in keeping with rates of 26–50% quoted for general medical and surgical ICU readmissions, which are about two to three times that of the unit as a whole [1,2,16,21]. The most common mode of death was of primary cardiac origin, reflecting decreased cardiac functional reserve.

Postoperative morbidity is notably the major contributor to quality of life and hospital cost following surgery [22]. Readmissions to the ICU provide good argument for the establishment of an intermediary care unit prior to the general ward to avoid premature discharge of patients [23]. This argument is supported by Fox and colleagues [24] who prospectively analysed the dependency status of 88 critical care patients since the opening of their high dependency unit (HDU), having no patient readmissions to the ICU, compared with five out of 60 patients in their previous study [25]. As not all readmissions require reventilation, these patients would essentially fulfil the criteria for HDU level therapy. From a financial standpoint, the current average daily cost of a National Health Service (NHS) hospital ICU bed to be about GB£1000, compared with about GB£300 for an HDU bed.

While mortality is regarded as the most important performance indicator of heart surgery and is the usual end-point of risk-stratification analyses, the diversity of non-fatal outcomes makes morbidity prediction difficult. Undoubtedly, the robustness of any morbidity prediction model would depend on the selection of adverse outcome measures. Since many of the factors were inter-related, any individual model is not a uniquely good predictor and other models could be developed which could have similar predictive value. The risk factors for prediction of mortality as used in Parsonnet and EuroSCORE systems may differ significantly from those for morbidity. Our study acts as a doorway into prediction of one of the most significant morbidity outcomes and serves to guide clinical decision-making in daily ICU discharges.

5. Conclusion

The readmission of cardiac surgical patients to the ICU is a major morbidity outcome associated with high mortality and often prolonged ventilation, in addition to high economic cost. A multivariate prediction model can be built around established risk stratification systems and include measures for obesity, operative urgency, and respiratory parameters. The commonest indications for ICU readmission are renal failure, cardiac arrest and respiratory failure. About half of all readmissions ultimately require reventilation; about half are suitable for HDU level management, at substantially less economic cost.

References

[1] Franklin C, Jackson D. Discharge decision-making in a medical ICU: characteristics of unexpected readmissions. Crit Care Med 1983;11:61–66.

[2] Durbin CGJ, Kopel RF. A case-control study of patients readmitted to the intensive care unit. Crit Care Med 1993;21:1547–1553.

[3] Singer DE, Carr PL, Mulley AG, Thibault GE. Rationing intensive care–physician responses to a resource shortage. N Engl J Med 1983;309:1155–1160.

[4] Strauss MJ, LoGerfo JP, Yeltatzie JA, Temkin N, Hudson LD. Rationing of intensive care unit services. An everyday occurrence. J Am Med Assoc 1986;255:1143–1146.

[5] Detsky AS, Redelmeier D, Abrams HB. What's wrong with decision analysis? Can the left brain influence the right? J Chronic Dis 1987;40:831–838.

[6] Byrick RJ, Power JD, Ycas JO, Brown KA. Impact of an intermediate care area on ICU utilization after cardiac surgery. Crit Care Med 1986;14:869–872.

[7] Parsonnet V, Dean D, Bernstein AD. A method of uniform stratification of risk for evaluating the results of surgery in acquired adult heart disease [published erratum appears in Circulation 1990 Sep;82(3):1078]. Circulation 1989;79:I3–12.

[8] Nashef SA, Roques F, Michel P, Gauducheau E, Lemeshow S, Salamon R. European system for cardiac operative risk evaluation (EuroSCORE). Eur J Cardiothorac Surg 1999;16:9–13.

[9] Knaus WA, Wagner DP, Draper EA, Zimmerman JE, Bergner M, Bastos PG, Sirio CA, Murphy DJ, Lotring T, Damiano A, Harrell FE. The APACHE III prognostic system. Risk prediction of hospital mortality for critically ill hospitalized adults [see comments]. Chest 1991;100:1619–1636.

[10] Turnbull AD, Carlon G, Baron R, Sichel W, Young C, Howland W. The inverse relationship between cost and survival in the critically ill cancer patient. Crit Care Med 1979;7:20–23.

[11] Noseworthy TW, Jacobs P. Economic and ethical consideration in the intensive care unit. Health Care Manag Forum 1990;3:3–18.

[12] Holmes L, Loughead K, Treasure T, Gallivan S. Which patients will not benefit from further intensive care after cardiac surgery? [see comments]. Lancet 1994;344:1200–1202.

[13] Atkinson S, Bihari D, Smithies M, Daly K, Mason R, McColl I. Identification of futility in intensive care. Lancet 1994;344:1203–1206.

[14] Lipsett PA, Swoboda SM, Dickerson J, et al. Survival and functional outcome after prolonged intensive care unit stay. Ann Surg 2000;231(2):262–268.

[15] Le Gall J, Lemeshow S, Saulnier F. A new Simplified Acute Physiology Score (SAPS II) based on a European/North American multicenter study [published erratum appears in J Am Med Assoc 1994 May 4;271(17):1321]. J Am Med Assoc 1993;270:2957–2963.

[16] Lemeshow S, Teres D, Klar J, Avrunin JS, Gehlbach SH, Rapoport J. Mortality Probability Models (MPM II) based on an international cohort of intensive care unit patients. J Am Med Assoc 1993;270:2478–2486.

[17] Turner JS, Morgan CJ, Thakrar B, Pepper JR. Difficulties in predicting outcome in cardiac surgery patients. Crit Care Med 1995;23:1843–1850.

[18] Snow N, Bergin KT, Horrigan TP. Readmission of patients to the surgical intensive care unit: patient profiles and possibilities for prevention. Crit Care Med 1985;13:961–964.

[19] Baigelman W, Katz R, Geary G. Patient readmission to critical care units during the same hospitalization at a community teaching hospital. Intensive Care Med 1983;9:253–256.

[20] Rubins HB, Moskowitz MA. Discharge decision-making in a medical intensive care unit. Identifying patients at high risk of unexpected death or unit readmission. Am J Med 1988;84:863–869.
[21] Chen LM, Martin CM, Keenan SP, Sibbald WJ. Patients readmitted to the intensive care unit during the same hospitalization: clinical features and outcomes [see comments]. Crit Care Med 1998;26:1834–1841.
[22] Higgins TL. Quantifying risk and assessing outcome in cardiac surgery. J Cardiothorac Vasc Anesth 1998;12:330–340.
[23] Leeson-Payne CG, Aitkenhead AR. A prospective study to assess the demand for a high dependency unit [see comments]. Anaesthesia 1995;50:383–387.
[24] Fox AJ, Owen-Smith O, Spiers P. The immediate impact of opening an adult high dependency unit on intensive care unit occupancy. Anaesthesia 1999;54:280–283.
[25] Thompson H, Spiers P. Occupancy of a teaching hospital adult intensive care unit by high dependency patients [see comments]. Anaesthesia 1998;53:589–592.