

# Predictors of in-hospital mortality following redo cardiac surgery: Single center experience

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**Abstract:** *Purpose:* Redo cardiac operations represent one of the main challenges in heart surgery. The purpose of the study was to analyze the predictors of in-hospital mortality in patients undergoing reoperative cardiac surgery by a single surgical team. *Methods:* A total of 1367 patients underwent cardiac surgical procedures and prospectively entered into a computerized database. Patients were divided into 2 groups based on the reoperative cardiac surgery ( $n = 109$ ) and control group ( $n = 1258$ ). Uni- and multivariate logistic regression analysis were performed to evaluate the possible predictors of hospital mortality. *Results:* Mean age was  $56 \pm 13$ , and 46% were female in redo group. In-hospital mortality was 4.6 vs. 2.2%,  $p = 0.11$ . EuroSCORE (6 vs. 3;  $p < 0.01$ ), cardiopulmonary bypass time (90 vs. 71 min;  $p < 0.01$ ), postoperative bleeding (450 vs. 350 ml;  $p < 0.01$ ), postoperative atrial fibrillation (AF) (29 vs. 16%;  $p < 0.01$ ), and inotropic support (58 vs. 31%;  $p = 0.001$ ) were significantly different. These variables were entered into uni- and multivariate regression analysis. Postoperative AF (OR 1.76,  $p = 0.007$ ) and EuroSCORE (OR 1.42,  $p < 0.01$ ) were significant risk factors predicting hospital mortality. *Conclusions:* Reoperative cardiac surgery can be performed under similar risks as primary operations. Postoperative AF and EuroSCORE are predictors of in-hospital mortality for redo cases.

**Keywords:** redo cardiac surgery, hospital mortality, risk factors

## Introduction

Having increased operative and technical skills and improved long-term survival after cardiac surgery, in recent years, surgeons inclined to perform redo cardiac surgery instead of medical therapy or other cardiac interventions [1, 2]. Patients with previous coronary artery bypass surgery (CABG) tend to have more complex disease (high SYNTAX scores), and morbidity is significantly higher with percutaneous coronary interventions [3]. Even incomplete revascularization is not associated with adverse events during follow-up after CABG [4]. Moreover, redo CABG is nearly as safe as the primary operation [5]. Redo surgery is inevitable in patients with prosthetic heart valves that carry similar morbidity and mortality compared to primary replacement [6]. However, mortality seems as much higher as main surgery [7]. Therefore, we intended to report the surgical outcome and determine the predictors that could influ-

ence or help in the decision to offer medical vs. surgical therapy.

## Patients and Methods

In a retrospective design, we have collected the data of 1367 consecutive patients who underwent open heart surgery between 2010 and 2014. Clinical information was stored prospectively in a computerized database. All patients were operated by the same surgical team in a single center. Of 1367 patients, 109 had redo cardiac surgery. The rest of the population comprised the control group ( $n = 1258$ ).

### Exclusion criteria

Patients were excluded from this analysis if they 1) required cardiopulmonary resuscitation before opera-

tion, 2) underwent an acute aortic dissection surgery, or 3) underwent thoracic and aortic aneurysm surgical procedures.

#### *Preoperative evaluation*

For all patients scheduled for redo cardiac surgery, we instituted preoperative evaluation of atherosclerosis of the ascending aorta, the aortic arch, and the descending aorta. In patients older than 70 years, this assessment was done by using computed tomography (CT). In those younger than 70 years, CT was only done if there was carotid bruit, history of stroke, presence of diabetes mellitus, peripheral vascular disease or left main coronary artery disease, and/or detection of calcification in the aortic arch on chest X-ray films. Carotid artery Doppler ultrasound was performed in all patients older than 60 years of age; in patients with carotid bruit; those with a history of stroke; those with diabetes mellitus, peripheral vascular disease, or left main coronary artery disease; and those with aortic calcification on chest radiography. Cardiac functions were evaluated by using GE/VingMed Vivid 7 digital transthoracic echocardiography (GE Vingmed Ultrasound; GE Vingmed Ultrasound AS, Horten, Norway).

#### *Surgical techniques*

Three different operative strategies were used to perform CABG: 1) cardiopulmonary bypass (CPB) (on-pump) with arrested heart (conventional CABG); 2) on-pump with beating heart; and 3) off-pump beating heart. The decision whether a patient would undergo the procedure on-pump CABG, on-pump with beating heart, or off-pump beating heart was made by the same surgeons (I.C. and O.G.) according to the severity of coronary artery disease, ascending aortic atherosclerosis, and the degree of cardiomegaly, and other diseases. For most of this series, conventional surgery was the standard strategy. In each of the 1367 subjects, the ascending aorta was routinely assessed by intraoperative aortic palpation using the method described by Mills and Everson [8]. The patients with calcified aorta (i.e., unclampable ascending aorta) were operated with no-touch aorta technique.

#### *Redo cardiac surgery technique*

In 27 cases, the right common femoral artery and the right common femoral vein cannulation; in 78 cases, aorta–right atrial cannulation; and in 3 cases, axillary artery–right femoral vein cannulation were prepared initially. An oscillating saw was used to divide the sternum. Once the posterior table of the sternum was divided

with the saw, the wires were removed and a sharp dissection was done with electrocautery and/or scissors to separate each side of the sternum from the underlying structures. The dissection plane was close to the sternum and developed along the diaphragmatic surface and then up around the right atrium towards the aorta. Dissection on the aorta was performed slowly and diligently to avoid penetration and extension beneath the adventitia. Dissection of the left heart was completed on CPB. The heart was not dissected more than necessary to perform the planned operation safely. The patent left internal thoracic artery was isolated and controlled either before or after the initiation of CPB. In control group, patients were cannulated through aorta–right atrium in a standard manner.

The cardiopulmonary bypass was initiated, and mild systemic hypothermia (30–32 °C) was achieved. Antegrade blood cardioplegia in induction and continuous retrograde blood cardioplegia in maintenance were used for myocardial protection.

#### **Statistical Analyses**

Statistical analysis was performed using SPSS software (Version 17.0, SPSS Inc., Chicago, IL, USA). All numerical data are expressed as mean values  $\pm$  SD or as proportions. Kolmogorov–Smirnov test was used to evaluate the normality of data. Continuous variables were compared by the use of Student *t*-test or Mann–Whitney *U* depending on parametric and nonparametric distribution, respectively. The categorical variables between the groups were analyzed by using the Chi square test or Fisher's exact test. A univariate analysis was done initially, and then, clinical variables that were identified as significantly associated with hospital mortality were included in a multivariate logistic regression. The odds ratio (OR) and 95% confidence interval (CI) were calculated for each factor in the presence of the others in the final model. The level for statistical significance was predetermined at  $p < 0.05$ .

#### **Results**

The mean age of the redo surgery patients was  $56 \pm 13$ , and 46% ( $n = 476$ ) were female. Redo cardiac surgery was performed in 7.9% (109/1367). Hospital mortality was 4.6 vs. 2.2% ( $p = 0.11$ ). CABG (48.6%) was the most frequently performed surgery in redo group. Mean interval between primary and secondary operations was  $9.7 \pm 5.9$  years.

Baseline clinical characteristics of the study cohort are summarized in *Table I*. Hypertension (45 vs. 56%;  $p = 0.02$ ), median EuroSCORE (6 vs. 3;  $p < 0.01$ ), preoperative atrial fibrillation (AF) (27.5 vs. 6.8%;  $p < 0.01$ ),

**Table I** | Baseline clinical characteristics

	Redo patients ( <i>n</i> = 109)	Control group ( <i>n</i> = 1258)	<i>p</i>
Age (years)	56 ± 13	62 ± 10	<0.01
Female gender	51 (46)	425 (33)	0.005
HTN	48 (45)	705 (56)	0.02
DM	39 (36)	557 (44)	0.07
HL	15 (14)	283 (22)	0.02
Smoking	20 (18)	372 (29)	0.009
COPD	13 (12)	124 (10)	0.29
MI	15 (13)	418 (33)	<0.01
Stroke/TIA	8 (7.3)	74 (6)	0.32
PVD	4 (3.4)	59 (4.7)	0.42
Renal failure	6 (5.7)	137 (10.9)	0.05
Infective endocarditis	6 (5.5)	12 (1)	0.002
AF	30 (27.5)	85 (6.8)	<0.01
CHF	3 (2.8)	54 (4.3)	0.31
LVEF %	60 (28–60)	62 (20–65)	0.54
≤30	6 (5.5)	101 (8)	
30.1–49	23 (21.1)	302 (24.1)	
≥50	80 (73.4)	852 (67)	0.44
EuroSCORE	6 (1–14)	3 (0–14)	<0.01
NYHA class III/IV	44 (40)	408 (32)	0.05
Status			0.54
Elective	100 (93.5)	1176 (93.6)	
Urgent/emergent	7 (6.5)	81 (6.4)	
Current operation			<0.01
CABG	53 (48.6)	1119 (88.9)	
Aortic valve surgery	32 (29.2)	124 (9.8)	
Mitral valve surgery	38 (34.8)	154 (12.2)	
Tricuspid valve surgery	17 (15.6)	22 (1.7)	
Aortic surgery	8 (7.3)	50 (3.9)	
Previous operation			
CABG	63 (57.8)		
Aortic valve	21 (19.2)		
Mitral valve	33 (30.3)		
Tricuspid valve	3 (2.7)		
Aortic surgery	4 (3.6)		
VSD closure	2 (1.8)		

Numbers are given as mean ± SD, median (minimum–maximum) or numbers (percentage). LVEF indicates left ventricular ejection fraction; CABG, coronary bypass grafting; PVD, peripheral vascular disease; TIA, transient ischemic attack; COPD, chronic obstructive pulmonary disease; EuroSCORE, European System for Cardiac Operative Risk Evaluation; NYHA, New York Heart Association; VSD, ventricular septal defect

and infective endocarditis (5.5 vs. 1%;  $p = 0.002$ ) were significantly different between groups.

Surgical outcomes were summarized in *Table II*. Median duration of cardiopulmonary bypass time (90 vs. 71 min;  $p < 0.01$ ), length of hospital stay (4 vs. 4 days;

$p = 0.05$ ), and postoperative bleeding (450 vs. 350 mL;  $p < 0.01$ ) were significantly different between groups. Postoperative AF (29 vs. 16%;  $p < 0.01$ ), inotrope support (58 vs. 31%;  $p = 0.001$ ), intra-aortic balloon pump (IABP) support (2.8 vs. 0.6%;  $p = 0.03$ ), reexploration

Table II | Postoperative results

	Redo patients (n = 109)	Control group (n = 1257)	p
On-pump with arrested heart	102 (93.6)	1141 (90.7)	0.20
On-pump with beating heart	3 (2.8)	111 (8.8)	0.01
Off-pump with beating heart	4 (3.7)	6 (0.5)	0.006
CPB time (min)	90 (31–294)	71 (17–255)	<0.01
Cross clamp time (min)	65 (13–164)	58 (10–168)	0.001
No-touch aortic technique	2 (1.8)	46 (3.7)	0.24
Use of bypass graft			
Bypass graft	3 (1–5)	4 (1–6)	0.005
LIMA	28 (52.8)	863 (77)	<0.01
SVG	47 (88.6)	833 (74.4)	0.35
Radial artery	4 (7.5)	15 (1.3)	0.006
Mechanical support (hours)	14 (5–89)	14 (3–147)	0.12
ICU length of stay (days)	2 (1–25)	2 (1–27)	0.77
Length of hospital stay (days)	4 (4–25)	4 (3–52)	0.05
Postoperative bleeding (mL)	450 (50–1050)	350 (50–2250)	<0.01
Postoperative transfusion (Units)			
Packed red blood cells	2 (0–8)	2 (0–10)	0.18
Fresh frozen plasma	5 (0–26)	5 (0–27)	0.16
Postoperative complications			
Reexploration for bleeding	4 (3.7)	11 (0.9)	0.02
AF	32 (29)	207 (16)	<0.01
Gastrointestinal complication	1 (0.9)	3 (0.2)	0.28
Renal failure	8 (7)	166 (13)	0.06
Pulmoner complication	4 (3.7)	39 (3)	0.45
Stroke/TIA	1 (0.9)	28 (2.2)	0.31
Inotrope support	61 (58)	394 (31)	<0.01
IABP support	3 (2.8)	7 (0.6)	0.03
Mediastinitis	0	5 (0.4)	0.66
Wound infection	3 (2.8)	5 (0.4)	0.02

CPB indicates cardiopulmonary bypass; ICU, intensive care unit; IABP, intra-aortic balloon pump; LIMA, left internal mammary artery; SVG, saphenous vein graft

for bleeding (3.7 vs. 0.9%;  $p = 0.02$ ), and wound infection (2.8 vs. 0.4%;  $p = 0.02$ ) were significantly different between groups.

In redo cases, 5 (4.6%) patients died due to cardiac and multisystemic causes or injury. Mean age and EuroSCORE were 77 and 10.6, respectively, in this group.

#### Uni- and multivariate analysis

The variables in Tables I and II that were significantly different between two groups were entered into uni- and multivariate regression analysis. Postoperative AF and EuroSCORE exhibited both strong univariate [(OR 6.46; 95% CI 4.45–9.38,  $p < 0.01$ ) and (OR 1.46; 95%

CI 1.40–1.52,  $p < 0.01$ ), respectively] and multivariate associations [(OR 1.76; 95% CI 1.17–2.66,  $p = 0.007$ ) and (OR 1.42; 95% CI 1.36–1.49,  $p < 0.01$ ), respectively] with hospital mortality (Table III).

#### Discussion

Cardiac reoperations represent one of the main challenges in cardiac surgery. The reoperation rate for CABG is approximately 3% at 5 years and 11% at 10 years [2]. The number of patients undergoing reoperation for valvular heart disease is increasing as the general population ages [9]. Redo surgery is no longer a risk factor for poor outcome and can be done effectively

**Table III** | Uni- and multivariate analysis of clinical variables associated with in-hospital mortality

Variables	Univariate			Multivariate		
	OR	95% CI	<i>p</i>	OR	95% CI	<i>p</i>
Age	1.04	1.03–1.04	<0.01			
Infective endocarditis	6.0	2.2–16.4	0.002			
Preoperative AF	3.8	1.6–8.6	0.001			
Inotrope support	6.4	2.8–14.3	<0.01			
Duration of CPB time	0.9	0.9–0.9	<0.01			
Postoperative bleeding	0.9	0.9–1.0	<0.01			
IABP support	2.33	0.60–9.02	0.22			
EuroSCORE	1.46	1.40–1.52	<0.01	1.42	1.36–1.49	<0.01
Postoperative AF	6.46	4.45–9.38	<0.01	1.76	1.17–2.66	0.007

OR indicates odds ratio; CI, confidence interval; AF, atrial fibrillation

with acceptable risks when specific multidisciplinary approaches are adopted [10]. In the current era, redo CABG is nearly as safe as the primary operation [2]. Reoperative surgery even for an elderly patient with isolated aortic or mitral valve pathology is associated with excellent long-term survival. However, valve reoperations may have higher risk when patients are not referred and operated on early before they develop severe symptoms [5, 11]. Although in-hospital mortality seems higher among the elderly than among younger patients, redo valvular surgery in an elderly cohort can be performed with acceptable morbidity and mortality. Expected survival is higher than that without surgical intervention. Despite increased resource utilization, elderly patients can be offered redo surgical intervention for valvular heart disease [12]. In this regard, our study determined in-hospital mortality after redo surgery is similar to that of primary operation and accords with the aforementioned findings. Conversely, unlike the previous reports, our study group comprised both valvular and CABG reoperations together. Some cases underwent both CABG and valve surgery at the same time. In such a heterogeneous study group with higher EuroSCORE values, we believe that our results differ from other studied patient groups.

Adverse events occur regularly during cardiac reoperation and are related to complexity of the procedure. Adverse events happen particularly during dissection and often when preventive strategies have not been used. Compensatory rescue measures are not always successful. Adverse events lead to poor patient outcome and higher cost [13]. As anticipated, adverse events affecting mortality have been developed in the presented study. Postoperative AF and high EuroSCORE values were related to mortality in the study group.

It was reported in a study that advanced NYHA functional class was independent predictor of hospital mortality in patients submitted for valvular reoperations

for prosthetic valve dysfunction [14]. In a failing heart, IABP represents an option of left ventricular support. The need for IABP especially in a high risk valve population is associated with early unfavorable outcome [15]. On the contrary, our study did not demonstrate a benefit from IABP use.

EuroSCORE accurately predicts short and mid-term mortality in combined aortic valve replacement and coronary artery bypass patients [16]. In high-risk patients with complex coronary artery disease (i.e., EuroSCORE >5), CABG is superior to other coronary revascularization procedures. AF after cardiac surgery occurs in approximately one third of patients and is associated with an increase in adverse events and in-hospital mortality [17]. Our results determined that AF is a predictor of hospital mortality after cardiac reoperations as well.

### Limitations

Although all data were collected prospectively, the design of this study is retrospective. Cases underwent surgery in a single center, and possible selection bias makes the results unable to be applied to the general population. Furthermore, databases may underreport events and risk factors. Therefore, conclusions are necessarily limited in their application.

### Conclusions

In conclusion, redo cardiac surgery can be performed under similar risks as primary operation either CABG, aortic, or valve surgery. New onset AF and higher EuroSCORE values predict in-hospital mortality following cardiac reoperations.

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## References

- Keeling WB, Leshnower BG, Thourani VH, Kilgo PS, Chen EP: Outcomes following redo sternotomy for aortic surgery. *Interact Cardiovasc Thorac Surg* 15, 63–68 (2012)
- Di Mauro M, Iacò AL, Contini M, Teodori G, Vitolla G, Pano M, Di Giammarco G, Calafiore AM: Reoperative coronary artery bypass grafting: analysis of early and late outcomes. *Ann Thorac Surg* 79, 81–87 (2005)
- Kappetein AP, Feldman TE, Mack MJ, Morice MC, Holmes DR, Ståhle E, Dawkins KD, Mohr FW, Serruys PW, Colombo A: Comparison of coronary bypass surgery with drug-eluting stenting for the treatment of left main and/or three-vessel disease: 3-year follow-up of the SYNTAX trial. *Eur Heart J* 32, 2125–2134 (2011)
- Head SJ, Mack MJ, Holmes DR Jr, Mohr FW, Morice MC, Serruys PW, Kappetein AP: Incidence, predictors and outcomes of incomplete revascularization after percutaneous coronary intervention and coronary artery bypass grafting: a subgroup analysis of 3-year SYNTAX data. *Eur J Cardiothorac Surg* 41, 535–541 (2012)
- Ngaage DL, Cowen ME, Griffin S, Guvendik L, Cale AR: The impact of symptom severity on cardiac reoperative risk: early referral and reoperation is warranted. *Eur J Cardiothorac Surg* 32, 623–628 (2007)
- LaPar DJ, Yang Z, Stukenborg GJ, Peeler BB, Kern JA, Kron IL, Ailawadi G: Outcomes of reoperative aortic valve replacement after previous sternotomy. *J Thorac Cardiovasc Surg* 139, 263–272 (2010)
- Park CB, Suri RM, Burkhart HM, Greason KL, Dearani JA, Schaff HV, Sundt TM 3rd: Identifying patients at particular risk of injury during repeat sternotomy: analysis of 2555 cardiac reoperations. *J Thorac Cardiovasc Surg* 140, 1028–1035 (2010)
- Mills NL, Everson CT: Atherosclerosis of the ascending aorta and coronary artery bypass. Pathology, clinical correlates, and operative management. *J Thorac Cardiovasc Surg* 102, 546–553 (1991)
- Fukunaga N, Okada Y, Konishi Y, Murashita T, Kanemitsu H, Koyama T: Redo valvular surgery in elderly patients aged >75 years. *J Heart Valve Dis* 23, 228–234 (2014)
- Tekumit H, Cenal AR, Tataroğlu C, Uzun K, Akıncı E: Early outcomes of cardiac reoperations: seven years of experience. *Turk J Thorac Cardiovasc Surg* 17, 145–150 (2009)
- Balsam LB, Grossi EA, Greenhouse DG, Ursomanno P, Deanda A, Ribakove GH, Culliford AT, Galloway AC: Reoperative valve surgery in the elderly: predictors of risk and long-term survival. *Ann Thorac Surg* 90, 1195–2000 (2010)
- Maganti M, Rao V, Armstrong S, Feindel CM, Scully HE, David TE: Redo valvular surgery in elderly patients. *Ann Thorac Surg* 87, 521–525 (2009)
- Roselli EE, Pettersson GB, Blackstone EH, Brizzio ME, Houghtaling PL, Hauck R, Burke JM, Lytle BW: Adverse events during reoperative cardiac surgery: frequency, characterization, and rescue. *J Thorac Cardiovasc Surg* 135, 316–323 (2008)
- de Almeida Brandão CM, Pomerantzeff PM, Souza LR, Tarasoutchi F, Grimberg M, Ramires JA, Almeida de Oliveira S: Multivariate analysis of risk factors for hospital mortality in valvular reoperations for prosthetic valve dysfunction. *Eur J Cardiothorac Surg* 22, 922–926 (2002)
- Parissis H, Leotsinidis M, Akbar MT, Apostolakis E, Dougenis D: The need for intra aortic balloon pump support following open heart surgery: risk analysis and outcome. *J Cardiothorac Surg* 5, 5–20 (2010)
- Kobayashi KJ, Williams JA, Nwakanma LU, Weiss ES, Gott VL, Baumgartner WA, Conte JV: EuroSCORE predicts short- and mid-term mortality in combined aortic valve replacement and coronary artery bypass patients. *J Card Surg* 24, 637–643 (2009)
- Girerd N, Pibarot P, Daleau P, Voisine P, O'Hara G, Després JP, Mathieu P: Statins reduce short- and long-term mortality associated with postoperative atrial fibrillation after coronary artery bypass grafting: impact of postoperative atrial fibrillation and statin therapy on survival. *Clin Cardiol* 35, 430–436 (2012)