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Early readmissions after isolated coronary artery bypass grafting

Running title: Early readmissions after isolated CABG

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Dear editor,

Since its introduction, coronary artery bypass grafting (CABG) has been the revascularisation intervention of choice in patients with complex coronary artery disease [1]. CABG is the most common cardiac surgical procedure [3]. Those reshospitalised within 30 days of discharge incur greater healthcare costs and have worse prognoses [4,5].

Although several studies have considered the subject, there is still inconsistent data regarding the causes of 30-day readmission after CABG. The majority of previous studies have reported data derived from the USA, the results of which may not be generalizable to other populations [4,6,7,8]. To evaluate the incidence, causes and predictors of 30-day readmission after CABG, we performed the first study of a contemporary cohort of patients in a large UK tertiary hospital.

The cohort for this retrospective audit was obtained from prospectively entered data from inpatient admissions following CABG between April 2012 and March 2017 at the Royal Stoke University Hospital (RSUH). Patients having other combined procedures or outside the catchment area for RSUH were excluded. The National Adult Cardiac Surgery Audit database was used to

identify potential participants and collect anonymised data on patient demographics, pre-operative risk factors, post-operative care and in-hospital mortality [9]. Patients' electronic records were retrospectively reviewed to identify reasons for readmission and care received prior to readmission. The official online calculator was used to calculate the EUROScore II, which is a validated risk of mortality score [10].

STATA 14 was used to perform data analysis of variance for continuous variables and chi-squared test for categorical variables. Multiple logistic regression was performed to identify predictors of 30-day readmission. Predictors with p-value <0.1 were included in a multivariate model using stepwise regression analysis to determine independent predictors of 30-day readmission.

Between 2012 and 2017, 659 patients were admitted to the Royal Stoke University Hospital for CABG (Figure 1). The majority of admissions occurred within the first week after discharge (Figure 2).

Patients who were readmitted within 30 days ($p < 0.05$) were more likely to be male, smokers, be diabetic or have renal disease or previous stroke (Table 1). Non-cardiac causes accounted for 80% of readmissions (Table 2). The most common causes of readmission were sternal wound infection (11.8%) and lower respiratory tract infection or exacerbation of COPD (10.5%). Female sex, diabetes, previous stroke, peripheral vascular disease and renal disease were all univariate predictors of readmission ($p<0.05$). Readmission was not associated with urgency of operation, number of grafts used, New York Heart Association (NYHA) score or EUROScore II (Table 3). Risk of readmission was lower in male patients (aOR 0.43 95%CI 0.23-0.79). Positive predictors of readmission included renal disease (aOR 2.03 95%CI 1.21-3.43), previous stroke (aOR 2.81 95%CI 1.25-6.29) and diabetes (aOR 1.99 95%CI 1.17-3.38) (Table 4).

The current analysis shows that readmission is common and most often due to non-cardiac causes such as sternal wound infections. Readmissions are more frequent in certain patient groups and characterisation of these factors will facilitate the prediction of risk of readmission.

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Table 1: Patient demographics

Variable	No readmission and alive (n=572)	30-day readmission (n=77)	p-value
Age	66.3±9.1	67.4±9.3	0.33
Male sex	484 (84.6%)	55 (71.4%)	0.004
Current or ex-smoker	383 (67.0%)	61 (79.2%)	0.030
Body mass index	29.7±5.2	29.6±3.8	0.97
Poor mobility	35 (6.6%)	5 (6.8%)	0.95
Dyspnea			0.23
No limitation	127 (22.3%)	12 (15.6%)	
Slight limitation	332 (58.3%)	43 (55.8%)	
Marked limitation	98 (17.2%)	19 (24.7%)	
Limited at rest	13 (2.3%)	3 (3.9%)	
Hypertension	448 (79.2%)	63 (81.8%)	0.59
Diabetes	164 (28.7%)	34 (44.2%)	0.006
Angina pectoralis	419 (73.5%)	60 (77.9%)	0.41
Previous myocardial infarction	273 (47.9%)	36 (46.8%)	0.85
Previous stroke	47 (8.2%)	12 (15.6%)	0.035
Peripheral vascular disease	67 (11.7%)	11 (14.3%)	0.52
Lung disease	76 (13.3%)	17 (22.1%)	0.039
Renal disease	171 (32.2%)	37 (49.3%)	0.003
Atrial fibrillation	27 (4.7%)	6 (7.8%)	0.25
Urgency			0.89
Elective	291 (50.9%)	36 (46.8%)	
Urgent	15 (2.6%)	2 (2.6%)	
Emergency	1 (0.2%)	0 (0%)	
Salvage	265 (46.3%)	39 (50.7%)	
Minimally invasive coronary bypass grafting	32 (5.6%)	0 (0%)	-

No. of grafts			0.82
1	22 (3.9%)	1 (1.4%)	
2	134 (23.8%)	18 (24.7%)	
3	284 (50.4%)	41 (53.4%)	
4	112 (19.9%)	14 (17.8%)	
5	12 (2.1%)	2 (2.7%)	
Inotropes of left ventricular assist device use	174 (30.4%)	25 (32.5%)	0.71
Euroscore II	2.6±2.8	3.7±5.2	0.003
Ventilation (days)	0.5±4.4	0.1±0.5	0.46
Length of stay (days)	11.4±10.4	10.9±5.9	0.68
Any return to theatre	31 (5.4%)	3 (3.9%)	0.57
Any post-op in-hospital arrhythmia or pacing	200 (35.0%)	23 (29.9%)	0.38
Post-op transfusion	231 (40.4%)	27 (35.1%)	0.37
Post-op in-hospital lung complication	90 (15.7%)	9 (11.7%)	0.35
Post-op gastrointestinal complication	5 (1.0%)	0 (0%)	0.41
Post-op in-hospital wound infection	4 (0.7%)	0 (0%)	0.46
Post-op in-hospital stroke	7 (1.2%)	0 (0%)	0.33
Post-op in-hospital dialysis	4 (1.0%)	0 (0%)	0.46

Table 2: Causes of readmission at 30-days

Non-cardiac causes of readmission (n=61)	**Patients**	**%**
Sternal wound infection	9	11.8
Sternal wound dehiscence	1	1.3
Leg wound infection	2	2.6
Leg wound dehiscence	1	1.3
Cellulitis	3	3.9
Deep vein thrombosis	1	1.3
Leg swelling, deep vein thrombosis excluded	5	6.6
Non-cardiac chest pain	5	6.6
Renal failure	4	5.3
Lower respiratory tract infection or exacerbation of chronic obstructive pulmonary disease	8	10.5
Chest infection and atrial fibrillation	2	2.6
Pleural effusion	4	5.3
Pulmonary embolism	5	6.6
Shortness of breath	1	1.3
Viral illness	1	1.3
Syncope and pre-syncope	2	2.6
Superficial thrombophlebitis	1	1.3
Digoxin toxicity, renal impairment	1	1.3
Hyponatraemia	1	1.3
Gastroenteritis	1	1.3
Large bowel obstruction	1	1.3
Upper gastrointestinal bleed	1	1.3
Confusion	1	1.3
Cardiac causes of readmission (n=15)		
Heart failure or pulmonary oedema	6	7.9
Arrhythmia	4	5.3
Non-ST elevation myocardial infarction	3	3.9
Stable angina	1	1.3
Cardiac arrest	1	1.3
Total	76	100

Table 3: Univariate predictors of 30-day readmission with all variables in model (n=583)

Variable	Odds ratio (95%CI)	P-value
Age	0.91 (0.95-1.01)	0.18
Male sex	0.35 (0.18-0.67)	0.001
Current or ex-smoker	2.07 (1.04-4.09)	0.038
Body mass index	0.99 (0.93-1.04)	0.64
Poor mobility	0.55 (0.17-1.72)	0.30
New York Heart Association class		
Slight (II) vs no limitation (I)	1.37 (0.62-3.01)	0.44
Marked (III) vs no limitation (I)	1.96 (0.77-4.99)	0.16
Limited at rest (IV) vs no limitation (I)	2.16 (0.33-14.31)	0.42
Hypertension	0.76 (0.37-1.56)	0.46
Diabetes	2.22 (1.26-3.92)	0.006
Angina	0.93 (0.47-1.85)	0.84
Previous myocardial infarction	0.62 (0.33-1.17)	0.14
Previous stroke	3.16 (1.30-7.69)	0.011
Peripheral vascular disease	0.36 (0.13-0.95)	0.039
Lung disease	1.72 (0.85-3.48)	0.13
Renal disease	2.11 (1.09-4.07)	0.027
Atrial fibrillation	2.63 (0.90-7.63)	0.076
Urgency		
Emergency vs elective	0.42 (0.04-4.67)	0.48
Urgent vs elective	1.07 (0.57-2.03)	0.83
Number of grafts		
2 vs 1	3.02 (0.33-27.58)	0.33
3 vs 1	3.91 (0.44-34.49)	0.22
4 vs 1	3.24 (0.34-31.18)	0.31
5 vs 1	3.36 (0.16-71.77)	0.44
Inotrope or LV assist device	0.96 (0.49-1.87)	0.90
Euroscore II	1.12 (1.01-1.24)	0.030
Days of ventilation	0.73 (0.45-1.18)	0.20

Effect of length of stay and in-hospital complications on 30-day readmission adjusting for above variables (n=583)		
Length of stay	0.99 (0.94-1.04)	0.63
Any return to theatre	1.13 (0.27-4.72)	0.86
Any arrhythmia	0.62 (0.33-1.18)	0.15
Blood transfusion	0.63 (0.33-1.19)	0.16
Lung complication	0.40 (0.16-1.02)	0.055

Table 4: Multivariate predictors of 30-day readmission with stepwise regression with p<0.1 (n=583)

Variable	Odds ratio (95% CI)	P-value
Renal disease	2.03 (1.21-3.43)	0.008
Male sex	0.43 (0.23-0.79)	0.006
Current or ex-smoker	1.88 (0.99-3.56)	0.052
Previous stroke	2.81 (1.25-6.29)	0.012
Peripheral vascular disease	0.44 (0.18-1.08)	0.074
Chronic lung disease	1.75 (0.91-3.40)	0.096
Diabetes	1.99 (1.17-3.38)	0.011

Figure legends

Figure 1: Flow diagram of patients admitted for coronary artery bypass grafting (CABG) between 2012 and 2017 in Royal Stoke University Hospital

Figure 2: Timing of 30-day readmission rates