

New-Onset Atrial Fibrillation after Off-Pump Coronary Artery Bypass Grafting: Predictors and In-hospital Complications

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Research article

Keywords: OPCAB\atrial fibrillation\predictors; complications

Posted Date: May 11th, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-27299/v1>

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Abstract

Objective To explore risk factors and in-hospital complications of new-onset atrial fibrillation (AF) after off-pump coronary artery bypass grafting (OPCAB). Methods In this study of 1344 patients who underwent isolated OPCAB from 2012 to 2015, patients were divided into AF and non-AF group according to whether new-onset postoperative AF occurred. Results The incidence of new-onset AF after OPCAB was 28.57%, mainly appeared within the first 4 days after surgery. After binary logistic regression analysis, age, peripheral vascular disease, median-sternotomy OPCAB, mechanical ventilation time, IABP were independent predictors of AF ($p < 0.001$, OR 1.039, 95%CI 1.023-1.055; $p = 0.007$, OR 2.450, 95%CI 1.282-4.684; $p = 0.044$, OR 0.589, 95%CI 0.351-0.987; $p = 0.013$, OR 1.006, 95%CI 1.001-1.011; $p = 0.007$, OR 3.001, 95%CI 1.356-6.642, respectively). Patients with AF have a significant higher risk of reoperation, re-entry into ICU, re-intubation, postoperative myocardial infarction, renal failure, and death ($p = 0.013$, $p = 0.015$, $p < 0.001$, $p = 0.037$, $p < 0.001$, $p < 0.001$, respectively), also a longer re-ICU time ($p = 0.014$). Conclusion Advanced age, peripheral vascular disease, median-sternotomy OPCAB, mechanical ventilation time, IABP were independent predictors for new-onset AF after OPCAB. Postoperative AF was clearly associated with more in-hospital complications.

Background

Coronary artery bypass grafting (CABG) is a usual approach of surgical revascularization performed to relieve angina, bypass atherosclerotic narrowing and improve blood supply to coronary circulation. Atrial fibrillation (AF) remains the most common arrhythmia after CABG. The incidence of post-CABG AF has been reported between 5% and 50% [1][2][3][4], mainly occurring in the 2–4 days after surgery [3][5]. Postoperative AF is associated with worse patient mortality, prolonged hospital stay, hemodynamic disorders, and thromboembolism [6]. It is important to identify patients at high risk of developing postoperative AF, so that targeted prophylactic therapy can be given. Risk factors of AF found in previous studies include advanced age [4], left ventricular function [7], extracorporeal circulation [8], and so on. However, it is still unclear which factors have a significant impact on its occurrence after this procedure. Research on predictive factors of new-onset AF after CABG is still of great clinical significance.

Previous studies have found that inadequate myocardial protection during the cardiopulmonary bypass increase the risk of AF after CABG. Off-pump coronary artery bypass grafting (OPCAB) avoid the inherent risks of cardiopulmonary bypass and cardioplegic arrest, and it has less interference in patients' circulation [9]. At present, there are few studies on the risk factors of new-onset AF after OPCAB, and there is no consensus about predictive factors of post-OPCAB AF. Therefore, this study aims to explore the risk factors of new-onset AF after OPCAB and identify the potential impact of postoperative AF on the in-hospital complications.

Methods

A total of 1406 patients who underwent selected and isolated OPCAB in Peking University People's Hospital from January 1, 2012 to December 30, 2015 were selected for this study. The excluded criteria included history of AF, non-sinus rhythm, congenital heart disease, concomitant surgery, valvular heart disease, cardiac pacemaker implantation and incomplete clinical data. Sixty two patients were excluded, 22 of whom had a history of AF; 22 patients had incomplete data; 6 patients were non-sinus rhythm; 7 had pacemakers installed before surgery, and 5 had concomitant carotid endarterectomy. The final study cohort included 1344 patients. Patients were divided into AF group and non-AF group according to whether they had new-onset AF after OPCAB. AF was defined as any episode of AF noted by continuous ECG/telemetry monitoring, or documented by a physician in the chart, lasting for 30 s or more. This study was approved by the Ethics Committee of Peking university people's hospital.

The present study includes multiple pre, intra, and post OPCAB variables (Tables 1 and 2). Types of OPCAB include conventional median-sternotomy OPCAB (cOPCAB) and minimally invasive coronary artery bypass grafting (MID-OPCAB). The laboratory and ultrasound data are the values of the final check before surgery. Perioperative medicine history and in-hospital complications were recorded carefully. In our study, two researchers collected clinical data, and the data between them had a high consistency. If there were controversies, the two researchers negotiated and resolved.

Table 1
Preoperative characteristics of patients

	AF group n = 384	Non-AF group n = 960	P
Age(year)	64.14 ± 8.60	61.16 ± 8.90	<0.001
Male(n,%)	285(74.2%)	695(72.4%)	0.497
BMI(kg/m ²)	25.56 ± 3.25	25.91 ± 12.38	0.582
MI history(n,%)	137(35.7%)	309(32.2%)	0.220
Previous PCI (n,%)	35(9.1%)	86(9.0%)	0.928
Previous CABG(n,%)	2(0.5%)	9(0.9%)	0.738
Smoking situation			0.722
Previous smoking(n,%)	83(21.6%)	189(19.7%)	
Current smoking(n,%)	99(25.8%)	250(26.0%)	
Diabetes mellitus			0.192
Diet control(n,%)	25(6.5%)	59(6.1%)	
Oral medication(n,%)	71(18.5%)	167(17.4%)	
insulin(n,%)	48(12.5%)	86(9.0%)	
Hypertension(n,%)	235(61.2%)	564(58.8%)	0.409
Hyperlipidemia(n,%)	69(18.0%)	141(14.7%)	0.134
COPD(n,%)	7(1.8%)	11(1.1%)	0.329
Peripheral vascular disease(n,%)	21(5.5%)	24(2.5%)	0.006
Cerebrovascular disease(n,%)	54(14.1%)	116(12.1%)	0.324
Thyroid disease			0.473
Hypothyroidism(n,%)	4(1.0%)	8(0.8%)	
Hyperthyroidism(n,%)	3(0.8%)	3(0.3%)	
Coronary heart disease			0.730
stable angina (n,%)	114(29.7%)	315(32.8%)	
Unstable angina(n,%)	257(66.9%)	613(63.9%)	
STEMI(n,%)	7(1.8%)	16(1.7%)	
NSTEMI(n,%)	6(1.6%)	16(1.7%)	

	AF group n = 384	Non-AF group n = 960	P
NYHA Class			0.265
NYHA I(n,%)	49(12.8%)	133(13.9%)	
NYHA II(n,%)	195(50.8%)	504(52.5%)	
NYHA III(n,%)	127(33.1%)	280(29.2%)	
NYHA IV(n,%)	13(3.4%)	43(4.5%)	
Number of coronary artery lesion			0.045
1 vessel(n,%)	20(5.2%)	87(9.1%)	
2 vessel(n,%)	32(8.3%)	70(7.3%)	
3 vessel(n,%)	332(86.5%)	803(83.6%)	
4 vessel(n,%)	60(15.6%)	177(18.4%)	
Preoperative medications			
Nitrate(n,%)	223(58.1%)	542(56.5%)	0.589
Catecholamine(n,%)	3(0.8%)	8(0.8%)	1
Beta blockers(n,%)	348(90.6%)	882(91.9%)	0.457
ACEI/ARB(n,%)	103(26.8%)	233(24.3%)	0.329
Statins(n,%)	331(86.2%)	829(86.4%)	0.940
Aspirin(n,%)	305(79.4%)	752(78.3%)	0.658
Clopidogrel(n,%)	14(3.6%)	39(4.1%)	0.723
Creatinine(umol/L)	79.21 ± 47.09	74.81 ± 46.80	0.120
Total cholesterol(mmol/L)	4.00 ± 1.02	4.00 ± 1.03	0.972
LDL(mmol/L)	2.383 ± 0.82	2.38 ± 0.84	0.999
LVEF(%)	61.15(16,78.6)	63.60(24.9,85.6)	0.001
LVEDD(cm)	5.34 ± 3.39	5.29 ± 3.95	0.816
LVESD(cm)	3.53 ± 0.79	3.38 ± 1.18	0.026
Left atrium diameters(cm)	3.80(2.3,5.1)	3.60(2,6.4)	<0.001

AF group n = 384	Non-AF group n = 960	p
ACEI, ACE inhibitor; ARB, angiotensin receptor blocker; BMI, body mass index; CABG,coronary artery bypass grafting; COPD, chronic obstructive pulmonary disease; LDL, low-density lipoprotein; LVEF, left ventricular ejection fraction; LVEDD, left ventricular end diastolic diameter; LVESD left ventricular end systolic diameter;MI, Myocardial infarction; NSTEMI, non-ST-elevation myocardial infarction;NYHA, New York Heart Association; PCI, percutaneous coronary intervention; STEMI, ST-segment elevation myocardial infarction.		

All patients were admitted into ICU after surgery and underwent continuous hardwire monitoring of blood pressure, pulse, electrocardiogram. After the patient leaved the ICU, continuous telemetry monitoring of blood pressure, pulse, electrocardiogram would be performed until discharge. Patients were checked for blood tests, liver and kidney function immediately and daily after surgery. If the patient did not have any contraindications, nitroglycerin, β -blocker, and antiplatelet drugs were routinely given after the operation. No other prophylactic therapies were taken to prevent postoperative arrhythmia. Other drugs were given according to the patient's condition. If ECG monitoring showed that AF occurred, a 12-lead ECG and blood gas examination would be performed at the same time. And the patient would be given oral or intravenous amiodarone. All patients were converted into sinus rhythm before discharging. No patients required electrical cardioversion.

The Kolmogorov-Smirnov test was used to check the normality of continuous variables. If they conformed to the normal distribution, they were described by mean \pm standard deviation. Otherwise, they were described by median (minimum, maximum). Categorical variables were expressed as numbers and percentages. Continuous variables were analyzed by *t*-tested, and categorical variables were compared by Mann-Whitney *U* test or Chi-square test/ Fisher's exact test. Independent predictors of AF were then determined by a binary logistic regression analysis of those variables found to have a *P*-value < 0.10 on univariate analysis. A bilateral *p*-value < 0.05 were considered statistically significant. Statistical analyses were performed using SPSS 24.0.

Results

From January 1, 2012 to December 30, 2015, 384 of the 1344 patients (28.57) who underwent isolated OPCAB developed postoperative new-onset AF. The average age is 61.96 ± 9.03 years (29–84 years), 981 patients are males(73.0%). The majority of AF appeared within the first 4 days after surgery, and the peak frequency is in the 2nd postoperative day (Fig. 1).

Advanced age was associated with an increase in AF ($p < 0.001$), and the proportion of peripheral vascular diseases was significantly higher in patients with AF ($p = 0.006$). There was a significant difference in the number of coronary artery lesions between two groups ($p = 0.045$). Patients in AF group had a lower ejection fraction, larger LVESD and left atrium diameters compared to those without postoperative AF ($p = 0.001$, $p = 0.026$, $p < 0.001$, respectively). (Table 1)

In AF group, 93.5% of patients received cOPCAB and 6.5% underwent MID-OPCAB. Proportions of cOPCAB and MID-OPCAB in non-AF patients were 85.4% and 14.6%, respectively. There was a significant difference between the two types of OPCAB and AF ($p < 0.001$). In addition, ICU time and mechanical ventilation time were significantly longer in the AF group ($p < 0.001$, $p < 0.001$, respectively). Patients with AF had a high risk of using IABP ($p < 0.001$), and they also had higher postoperative maximum TNI level ($p = 0.001$). There was no difference in the units of blood products transfused during surgery between two groups, but the total units of transfused red blood cells, plasma, and platelet in the AF group were significantly larger than that in the non-AF group ($p < 0.001$, $p < 0.001$ respectively). Patients with AF had more drainage after surgery ($p = 0.010$). (Table 2)

In a binary logistic regression analysis, age ($p < 0.001$, OR 1.039 [95%CI 1.023–1.055]), peripheral vascular disease ($p = 0.007$, OR 2.450 [95%CI 1.282–4.684]), cOPCAB ($p = 0.044$, OR 0.589 [95%CI 0.351–0.987]), mechanical ventilation time ($p = 0.013$, OR 1.006 [95%CI 1.001–1.011]), use of IABP ($p = 0.007$, OR 3.001 [95%CI 1.356–6.642]) remained independently predictive of new-onset AF after OPCAB. ICU time and mechanical ventilation time were all significantly different between two groups in the univariate analysis. However, after adjusted by binary logistic regression analysis, mechanical ventilation time was the only one significantly longer in the AF group (Table 3).

Table 2: Patients' intraoperative and postoperative characteristics

	AF group n = 384	Non-AF group n = 960	p
OPCAB			<0.001
cOPCAB(n,%)	359(93.5%)	820(85.4%)	
MID-OPCAB(n,%)	25(6.5%)	140(14.6%)	
Units of intraoperative blood products			
Red blood cells(U)	0.39 ± 1.18	0.40 ± 1.25	0.777
Plasma(ml)	32.81 ± 128.73	33.33 ± 119.67	0.946
Platelets(U)	0.01 ± 0.10	0	0.114
ICU time(h)	46.50(7,198.23)	39(5,500)	<0.001
Mechanical ventilation time(h)	17(2,1100)	12(0,465)	<0.001
IABP(n,%)	36(9.4%)	14(1.5%)	<0.001
Postoperative maximum TNI(ng/mL)	0.83(0.003–225.68)	0.64(0.01–234.20)	0.001
Total units of blood products			
Red blood cells(U)	4(0,124)	0(0,52)	<0.001
Plasma(ml)	800(0,7400)	600(0,6600)	<0.001
Platelets(U)	0(0,5)	0(0,5)	0.003
Drainage(mL)	980(170,5580)	930(100,5010)	0.010
cOPCAB, conventional median-sternotomy OPCAB; IABP, intra-aortic balloon pump; ICU, intensive care unit; MID-OPCAB, minimally invasive direct coronary artery bypass grafting; TNI, troponin-I.			

Patients in the AF group had more requirements for reoperation (5.5% vs 2.7%, $p = 0.013$), mainly due to bridge problems (vessel occlusion or insufficient blood flow), bleeding or pericardial tamponade, and chest incision problems (Fig. 2). The risks of re-entry into ICU, re-intubation, postoperative myocardial infarction, and renal failure in the AF group were significantly greater ($p = 0.015$; $p < 0.001$; $p = 0.037$; $p < 0.001$, respectively). Similarly, there was also a statistical difference in re-ICU time between the two groups ($p = 0.014$). In-hospital mortality was 22 patients (5.7%) in the AF group in comparison to 5 patients (0.5%) in the non-AF group with a p-value < 0.001 (Table 4).

Table 3
Table 3: Results of binary logistic regression analysis

	<i>p</i>	OR	95% CI
Age	<0.001	1.039	1.023–1.055
Peripheral vascular disease	0.007	2.450	1.282–4.684
cOPCAB	0.044	0.589	0.351–0.987
Mechanical ventilation time	0.013	1.006	1.001–1.011
IABP	0.007	3.001	1.356–6.642
cOPCAB, conventional median-sternotomy OPCAB; IABP, intra-aortic balloon pump.			

Table 4
In-hospital complications of patients

	AF group <i>n</i> = 384	Non-AF group <i>n</i> = 960	<i>p</i>
Reoperation(n,%)	21(5.5%)	26(2.7%)	0.013
Re-entry into ICU(n,%)	13(3.4%)	13(1.4%)	0.015
Re-ICU time(h)	0(0.408)	0(0.381)	0.014
Re-intubation(n,%)	15(3.9%)	6(0.6%)	<0.001
Myocardial infarction(n,%)	8(2.1%)	6(0.6%)	0.037
Stroke(n,%)	4(1.0%)	6(0.6%)	0.484
Renal failure(n,%)	36(9.4%)	7(0.7%)	<0.001
Death (n,%)	22(5.7%)	5(0.5%)	<0.001
ICU, intensive care unit.			

Discussion

The present study found that the new-onset AF after OPCAB was concentrated within the first 4 days after surgery, which is consistent with previous studies [3][5]. The incidence of AF in our study was 28.75% within the incidence of prior studies [1][2][3]. Age is one of the most consistent risk factors for postoperative AF in many previous literature [4][10][11][12][13][14][15], which was also supported by our research. The effect of advanced age on AF may relate to degenerative changes in atrial structure and function [11].

Studies have found that patients with peripheral vascular disease had a high probability of being accompanied by atherosclerosis of other blood vessels^[16], and the risk of cardiovascular events increases with the severity of peripheral vascular disease^{[17][18]}. Our study found that peripheral vascular disease was an independent risk factor for new-onset AF after OPCAB, which is consistent with the conclusions of Pollock et al. Their study included 9416 patients with isolated CABG in multiple centers, and found that patients with peripheral vascular disease were more likely to develop new-onset postoperative AF^[19].

OPCAB mainly includes two types of procedures: cOPCAB and MID-OPCAB. To our best knowledge, there are currently no studies especially focus on the relationship between the two types of OPCAB and postoperative new-onset AF. In this study, the binary logistic regression analysis showed that patients underwent cOPCAB had a significant more risk of postoperative AF than patients had MID-OPCAB. Nevertheless, it is also noteworthy that patients undergoing MID-OPCAB were younger, had better cardiac function and fewer coronary vessel lesions.

Most previous studies involved just one of ICU time and mechanical ventilation time, and rarely combined analysis of the two^{[12][20]}. Different from other studies, we included two variables mentioned above and found that only mechanical ventilation time was an independent risk factor of AF after OPCAB. Supporting our results, Filardo et al. had the same result from their study^[3], and they reported that both ICU time and mechanical ventilation time were statistically associated with postoperative AF in the univariate analysis, but mechanical ventilation time is the only one correlated significantly with AF after analyzed by logistic analysis.

In the present study, the proportion of patients with AF using IABP was significantly higher than that of non-AF. IABP is not a variable often included in previous research. Consistent with our findings, Lewicki et al. conducted a study included 1836 patients who underwent CABG and identified that IABP was an independent predictor of new-onset AF after CABG^[15]. Inversely, Thoren et al. disagreed with this conclusion^[21]. It might be due to the fact that the majority of the operations (96%) were performed on-pump in their study cohort, which is dramatically different from ours.

New-onset AF was clearly associated with more in-hospital complications. Similar to previous studies, we found patients with postoperative AF had higher risk of reoperation, re-intubation, postoperative myocardial infarction, stroke, renal failure, and in-hospital death^{[2][6][15][22][23]}. However, we could not show any association between postoperative stroke and AF, which was supported by previous studies^{[2][6][22]}. This might result from the fact that our study excluded patients who underwent concomitant valve surgery and only concentrated on in-hospital complications. To our best knowledge, previous studies of AF after CABG did not include re-entry into ICU and re-ICU time. From our study, we, firstly, demonstrated that the two variables above are all statistically significant between the two groups.

This is a retrospective single center observational study. One of the major limitations is intrinsic to the observational nature of this study, which cannot adjust for unobserved or unknown confounders.

Furthermore, the Chinese patient population might limit the generalizability of these reported findings. Finally, given the AF definition that the abnormal atrial originated rhythm be documented for at least 30 s, it is possible that the overall rate for AF occurrences may have been underreported.

Conclusions

In summary, the present study found that the incidence of new-onset AF after OPCAB was 28.57%, which mainly occurred within the first 4 days after surgery. Age, peripheral vascular disease, cOPCAB, mechanical ventilation time, IABP use were independent predictors of new-onset AF after OPCAB. Patients with new-onset AF have significantly more in-hospital complications than those without AF.

Declarations

Ethics approval and consent to participate:

This study compiled with the Declaration of Helsinki and the study protocols were approved by the ethics committee of Peking university people's hospital. Waiving the requirement for obtaining written informed consents was allowed by the ethics committee of Peking university people's hospital, because the retrospective and observational nature of this study.

Consent for publication

Not applicable.

Availability of data and materials

All data generated or analysed during this study are included in this published article and its supplementary information files.

Competing interests

The authors declare that they have no competing interests.

Funding

Not applicable.

Authors' contributions

Xu Hao performed the statistical analysis, data curation and writing the original draft; Fan Guangpu performed the data Curation; Chen Yu is in charge of conceptualization, methodology and writing the editing. All authors read and approved the final manuscript.

Acknowledgements

Not applicable.

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Figures

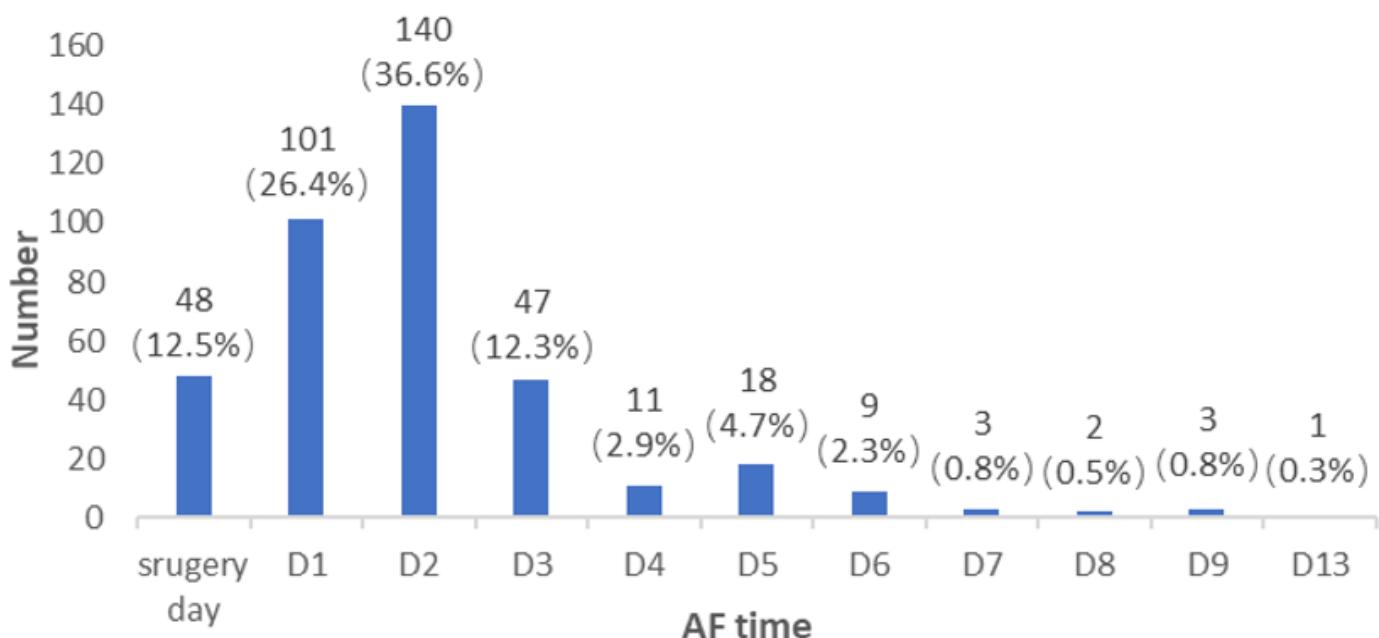


Figure 1: Time distribution of new-onset AF after OPCAB

Figure 1

Time distribution of new-onset AF after OPCAB

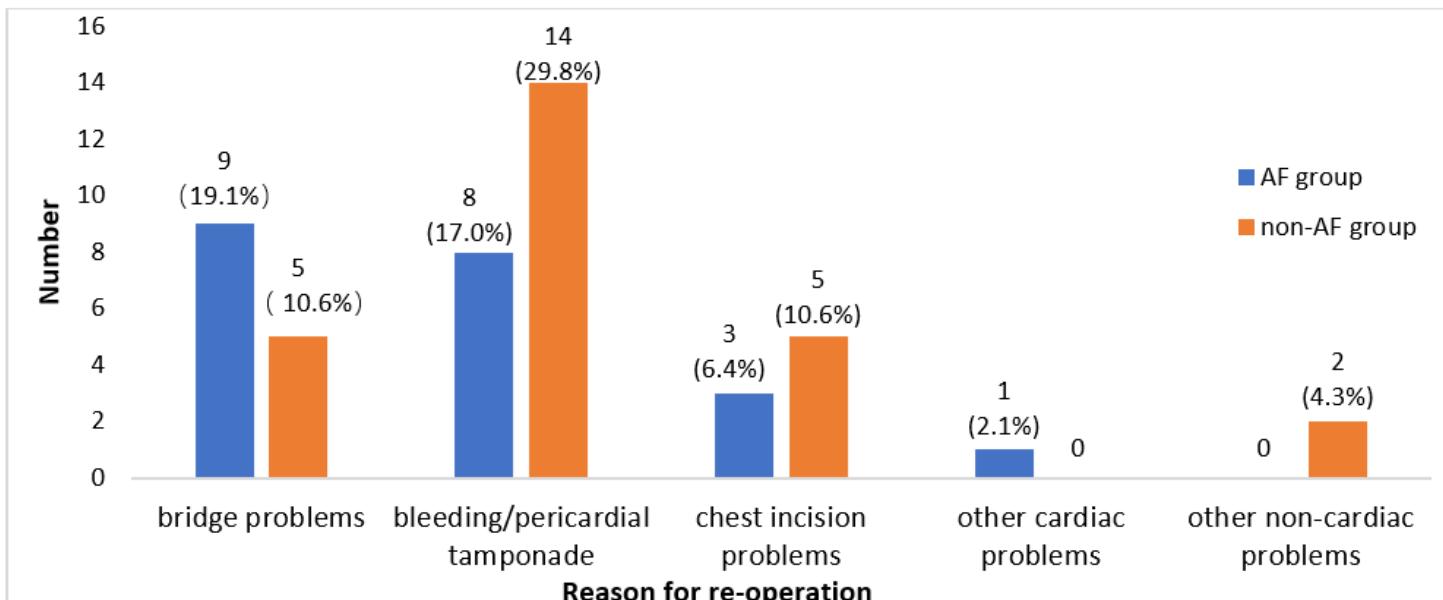


Figure 2: Distribution of causes for reoperation

Figure 2

Distribution of causes for reoperation