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Risk factors for postoperative delirium in patients after coronary artery bypass grafting: A prospective cohort study☆,☆☆,★

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ABSTRACT

Purpose: This study was designed to identify the incidence and independent perioperative risk factors associated with postoperative delirium of patients who underwent coronary artery bypass grafting (CABG) in a large intensive care unit setting in China.
Methods: Delirium was diagnosed by the confusion assessment method for the intensive care unit (CAM-ICU). Baseline demographics, perioperative data, and postoperative outcomes of 249 consecutive patients who underwent CABG were recorded prospectively and analyzed via univariate analysis and multivariate logistic regression to determine the independent risk factors of postoperative delirium.
Results: Postoperative delirium was detected in 76 patients according to CAM-ICU criteria. The incidence was 30.52%. Patients with and without delirium differed significantly on 34 variables ($P < .05$). Multivariate logistic regression analysis revealed that preoperative atrial fibrillation (odds ratio [OR], 3.957; 95% confidence interval [CI], 1.727-9.066), elevated European system for cardiac operative risk evaluation (OR, 1.178; 95% CI, 1.018-1.364), cognitive impairment (OR, 3.231; 95% CI, 1.008-10.356), prolonged surgery duration (OR, 1.008; 95% CI, 1.003-1.014), postoperative poor quality of sleep (OR, 5.001; 95% CI, 2.476-10.101), and electrolyte disturbance (OR, 2.095; 95% CI, 1.041-4.216) were independently associated with postoperative delirium after CABG.
Conclusions: Delirium is a frequent complication. Factors independently associated with delirium are preoperative atrial fibrillation, elevated European system for cardiac operative risk evaluation and cognitive impairment, longer surgery duration, postoperative poor quality of sleep, and electrolyte disturbance. The study may be helpful in decreasing the incidence of postoperative delirium after CABG by treating these predictors properly.

1. Introduction

With the improvement of global living standards, more people now have coronary artery disease. Coronary artery bypass grafting (CABG) is an effective method to relieve angina, improving life quality, and also reducing mortality and morbidity of coronary artery disease. During the postoperative period after CABG, patients are closely monitored for signs of insufficiency.

Delirium is defined as a disturbance of consciousness and cognition that presents during a short period (hours or days) and has a fluctuating course [1]. Advances in CABG practice have improved the outcomes of patients; however, delirium remains a frequent postoperative complication. The reported incidence of delirium after CABG varies to a large extent, ranging between 10.5% and 50.6% [2-5]. The wide range of reported incidences could be explained by the differences in the number and characteristics of the studied populations, the design and methods of the studies, the assessment of delirium, the differences in cardiac operative procedure, and perioperative management.

Generally, delirium is a serious problem because of its negative clinical outcomes, such as prolonged intensive care unit (ICU) stay and hospitalization, decreased cognitive functioning, higher mortality rate, and increased odds of institutionalization after discharge [6-8]. Fortunately, delirium is preventable [9]. The prevention of delirium has been demonstrated by modifying some crucial risk factors. Despite increasing interest in delirium, no thorough research on risk factors of postoperative delirium after CABG has been done in a large ICU in China. Therefore, the aim of our study was to obtain information about the incidence, risk factors, and clinical outcomes of delirium among our population that underwent CABG.

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Table 1
Perioperative risk factors of postoperative delirium in CABG patients (univariate analysis)[a]

Variable	With delirium, total n = 76, n (%)	No delirium, total n = 173 n (%)	*P*
Preoperative variables			
Age, y, mean (SD)	64.71 (9.95)	62.10 (9.08)	.0441
Male	63 (83)	134 (77)	.2067
BMI			
Underweight (BMI <18.5)	7 (9)	7 (4)	.7363
Normal (18.5 ≤ BMI < 24)	34 (45)	90 (52)	
Overweight (24 ≤ BMI < 28)	29 (38)	57 (33)	
Obesity (BMI ≥28)	6 (8)	19 (11)	
Education level			
Illiteracy	5 (7)	19 (11)	.6524
Primary school	21 (28)	32 (19)	
Middle school or above	50 (66)	122 (71)	
Hearing or language barrier	7 (9)	4 (2)	.0147
Tobacco use (3 mo before operation)	35 (46)	75 (43)	.6928
Alcohol use (3 mo before operation)	42 (55)	74 (57)	.0689
Diabetes mellitus	29 (38)	45 (26)	.0535
Hypertension	46 (61)	93 (54)	.3219
Predisposing cerebral disease	12 (16)	6 (3)	.0005
Predisposing cardiac surgery	5 (7)	2 (1)	.0171
Renal dysfunction (creatinine >110 mg/dL)	11 (14)	11 (5)	.0351
AF	26 (34)	16 (9)	<.0001
NYHA heart function			
Class I	1 (1)	7 (4)	.0337
Class II	22 (29)	67 (39)	
Class III	50 (66)	97 (56)	
Class IV	3 (4)	2 (1)	
EuroSCORE, mean (SD)	4.13 (2.57)	2.44 (2.16)	<.0001
LVEF <50%	15 (20)	23 (13)	.1930
Anemia	5 (7)	18 (10)	.3370
Carotid artery plaque	26 (34)	64 (37)	.6737
Anxiety (HAS ≥14)	12 (16)	10 (6)	.0104
Cognitive impairment (MMSE <27)	12 (16)	7 (4)	.0013
MRS, mean (SD)	1.38 (0.82)	1.16 (0.49)	.0095
Intraoperative variables			
Emergency operation	2 (3)	2 (1)	.4130
With CPB	71 (93)	163 (94)	.8087
Surgical type			
CABG	51 (67)	150 (87)	.0003
CABG +	25 (33)	23 (13)	
No. of distal anastomosis			
1	13 (17)	27 (16)	.7153
2	18 (24)	30 (17)	
3	24 (32)	72 (42)	
4	17 (22)	41 (24)	
5	4 (5)	3 (2)	
Surgery duration, min, mean (SD)	259.89 (80.97)	211.82 (54.64)	<.0001
Hypoxia (PaO_2 <60 mm Hg)	8 (11)	5 (3)	.0176
Blood transfusion >1 L	9 (12)	11 (6)	.1426
Postoperative variables			
Blood transfusion >1 L	31 (41)	25 (14)	<.0001
Sedation treatment	71 (93)	127 (73)	.0003
Type of inotropic medication			
None	–	4 (2)	<.0001
1	37 (49)	140 (81)	
2	28 (37)	25 (14)	
3	10 (13)	4 (2)	
4	1 (1)	0	
Duration of inotropic medication, d, mean (SD)	8.18 (8.95)	4.34 (2.81)	<.0001
Duration of mechanic ventilation, h, median (IQRs)	21.5 (17.0, 45.5)	19.0 (14.0, 21.0)	<.0001
Analgesia use	34 (45)	33 (19)	<.0001
Higher creatinine	17 (22)	12 (7)	.0005
AF	27 (36)	15 (9)	<.0001
HCT, %, mean (SD)	33 (5)	34 (4)	.0952
Low cardiac output (CI)	18 (24)	10 (6)	<.0001
Hypoxia (PaO_2 <60 mm Hg)	22 (29)	19 (11)	.0004
Quality of sleep			
Good	2 (3)	2 (1)	<.0001
Moderate	38 (50)	150 (87)	
Bad	36 (47)	21 (12)	
Mobilization			
Good	5 (7)	13 (8)	<.0001
Average	41 (54)	141 (82)	
Bad	30 (39)	19 (11)	

(continued on next page)

Table 1 *(continued)*

Variable	With delirium, total n = 76, n (%)	No delirium, total n = 173 n (%)	*P*
Diuresis treatment	75 (99)	151 (87)	.0042
Hypercarbia ($PCO_2 \geq 45$ mm Hg)	13 (17)	6 (3)	.0002
Postoperative complication	60 (79)	106 (61)	.0064
System involved in complications			
Cardiovascular system	35 (46)	18 (10)	.0021
Respiratory system	54 (71)	84 (49)	
Neurologic system	3 (4)	1 (1)	
Reoperation for bleeding	8 (11)	4 (2)	.0081
Acute infection	30 (39)	39 (23)	.0060
Pain severity			
No pain	13 (17)	27 (16)	.0560
Mild level	52 (68)	144 (83)	
Middle level	11 (14)	2 (1)	
Electrolyte disturbance	56 (74)	85 (49)	.0003

BMI indicates body mass index; LVEF, left ventricular ejection fraction; HAS, Hamilton Anxiety Scale; CABG+, have CABG and cardiac valve replacement, aortic repair, or lobectomy of lung simultaneously; HCT = hematocrit.

[a] Data are presented as the number and the percentage (%) with the characteristic except where indicated.

2. Material and methods

2.1. Study design

The study was a prospective cohort study. The data were collected in a cardiovascular ICU. The framework of likely risk factors (Table 1) was modified from several reports. The delirium was diagnosed according to the criteria of the confusion assessment method for the ICU (CAM-ICU), assessed 3 times a day (8:00, 16:00, and 24:00), and if the patient developed mental change. Baseline demographics, operative data, and postoperative outcomes were recorded prospectively by using standardized data entry form. The study was approved by the Ethics Review Committee of Changhai Hospital (CHEC2014-199), and each patient in our study signed informed consent.

2.2. Study populations

In this study, the sample was calculated using the number of risk factors of postoperative delirium after CABG. The sample was equal to 5 to 10 times the number of researched variables according to an empirical formula of sample-size estimation. Based on the results of empirical and clinical studies, 49 variables were included in this study. We calculated that a sample size of at least 245 cases would be necessary in the study interval.

Two hundred forty-nine consecutive ICU patients after CABG were prospectively studied during an 8-month interval in 2013. Patients who underwent CABG procedure and were admitted to the cardiovascular ICU for postoperative care were eligible for inclusion. Patients were excluded from analysis for the following reasons: (1) Patients had preoperative diagnosed delirium, mental disease, and dementia; (2) patients could not awaken from surgery; (3) patients died on the day of surgery; (4) patients stayed in ICU less than 24 hours; (5) cases with incomplete data collection; and (6) patients were younger than 18 years old.

The patients received postoperative care in a 29-bed cardiovascular ICU of a university-affiliated tertiary care hospital in Shanghai, China (Changhai Hospital). The patients were arranged in an open space with 5 to 13 patients, under direct care of the ICU staff with 2 or 3 patients per 1 registered nurse. The physical environment was the same for all patients in this study, with visible daylight and a clock, and visitors came once a day in the afternoon from the first postoperative day. Surgical and anesthesia techniques and procedures remained similar during the study interval. Cardiopulmonary bypass (CPB) was performed in 94% (234 cases) of the operations, whereas 6% (15 cases) was performed off pump (off-pump coronary artery bypass [OPCAB]). Cardiopulmonary bypass was performed according to standard protocol, with mean arterial pressure at greater than or equal to 60 mm Hg and blood flow maintained at 2.4 L/min per square meter body surface area. Saphenous veins, the radial artery, and the internal mammary artery were used as "bridges" for myocardial revascularization. After surgery, patients were transferred to the cardiovascular ICU, where they received standard postoperative care. The patients were on a mechanical ventilator via endotracheal tube and sedated at 0 to −3 score on the Richmond Agitation and Sedation Scale (RASS) [10] and weaned from mechanical ventilation and extubated according to standard protocol. Criteria for extubation were the following: wakefulness, sufficiency breathing efforts, body core temperature greater than or equal to 36°C, hemodynamically stable or with low doses of inotropic support, no active bleeding, and no shivering. All the patients had soft wrist restraints to protect the position of catheters, tubes, and drains, while they were on the ventilator.

2.3. Delirium assessment

In this study, delirium was screened routinely according to CAM-ICU criteria with a 2-step method. The first step was to assess patients' consciousness by RASS. If patient's RASS score was from −3 to +4, then we moved onto the second step. If the RASS score was −4 (responsive only to physical stimulus) or −5 (unresponsive to physical and verbal stimulus), the patient was ineligible for CAM-ICU assessment. If the patients were sedated, the dose of sedation medication was adjusted, and the patient was assessed 20 minutes later. The second step was to assess delirium with CAM-ICU in a standardized manner. The criteria of CAM-ICU include 4 features: (1) acute onset of changes or fluctuations in the course of mental status in last 24 hours, (2) inattention, (3) disorganized thinking, and (4) altered level of consciousness (i.e., no alert.). Four individual features were assessed, and a final decision was made whether delirium was present. Delirium was considered present if feature (1) and (2) plus either feature (3) or (4) existed. In assessing the process, RASS is used to assess both sedation or agitation and altered level of consciousness. Any score other than 0 is a positive value for feature (4). Because patients in the ICU are at high risk for developing delirium, patients in this study were screened from the day of surgery to the sixth postoperative day while in the ICU. Assessment of delirium was performed by the patient's registered nurse trained to use CAM-ICU and was assured by ICU physicians who were involved in the patient's care.

2.4. Data collection

The variables that were potentially related to delirium development were considered in the following 3 categories: preoperative, intraoperative, and postoperative. All the perioperative variables included in the study were listed in Table 1. There were 21 preoperative risk factors, including demographic data (age, sex, body mass index, and education

Table 2
Multivariate, stepwise logistic regression analysis for predictors of postoperative delirium in CABG patients

Predictor	Regression coefficient	SE	*P*	OR	95% CI	Standardized partial regression coefficient
AF[a]	1.375	0.423	.001	3.957	1.727-9.066	0.285
Elevated EuroSCORE[a]	0.164	0.075	.028	1.178	1.018-1.364	0.219
Cognitive impairment[a]	1.173	0.594	.048	3.231	1.008-10.356	0.172
Duration of surgery[b]	0.008	0.003	.004	1.008	1.003-1.014	0.310
Poor quality of sleep[c]	1.610	0.359	<.0001	5.001	2.476-10.101	0.397
Electrolyte disturbance[c]	0.739	0.357	.038	2.095	1.041-4.216	0.202
Constant	−7.746	1.128	<.0001			

[a] Preoperative factor.
[b] Intraoperative factor.
[c] Postoperative factor.

level); general comorbidity (barrier of hearing or language, tobacco, or alcohol use 3 months before operation and diabetes mellitus treated with insulin or oral medication); and preoperative cardiovascular status, including hypertension, predisposing cerebral disease such as cerebral infarction or hemorrhage, previous cardiac surgery, renal insufficiency (creatinine >110 mg/dL), atrial fibrillation (AF), New York Heart Association (NYHA) heart function, European system for cardiac operative risk evaluation (EuroSCORE) [11], left ventricular ejection fraction less than 50%, anemia (hemoglobin level <120 g/L in men and <110 g/L in women), carotid artery plaques found by ultrasound, anxiety, cognitive impairment, and modified Rankin Scale (MRS) [12]. Anxiety was diagnosed by the Hamilton Anxiety Scale [13]. Cognitive state was tested using the Mini-Mental State Examination (MMSE) [14], which was also used to identify and record baseline mental state. There were 7 intraoperative variables in the study. They were emergency surgery, surgery duration, CPB or off pump, surgery type, numbers of distal anastomoses, hypoxia (PaO_2 <60 mm Hg), and blood product usage more than 1 L. There were 21 postoperative variables, including blood transfusion greater than 1 L, sedation treatment, analgesia treatment, type and duration of inotropic drugs, duration of intubation, renal insufficiency, AF, hematocrit, low cardiac output (cardiac index <2.2 L/min per square meter), hypoxia, poor quality of sleep, early mobilization, postoperative diuretics, hypercarbia ($PaCO_2 \geq 45$ mm Hg), postoperative complications and system involved (cardiovascular system [low cardiac output syndrome, hemorrhage, and arrhythmia], respiratory system (atelectasis, pneumonia, and moderate-to-severe pleural effusion) and neurologic system (symptomatic cerebral infraction and cerebral hemorrhage), reoperation for bleeding, acute infection, and electrolyte disturbance. Sleep quality was assessed by self-report by the patient [15]. Mobilization was assessed as good, average, and bad according to the willingness of the patient for postoperative early mobilization.

A researcher-designed checklist of 49 risk factors for delirium was used to collect the preoperative, intraoperative, and postoperative variables. For the nondelirious patients, the most severe score of the possible risk factors of the observation interval was used in the analysis. For the delirious patients, the most severe score before the onset of delirium was selected. All patient data were collected in a prospective way. The interrater reliability of researchers was 0.93 for the checklist, calculated from a sample of 20 patients. Postoperative outcomes were duration of ICU stay, duration of postoperative hospitalization, duration of hospitalization, and hospital expense.

2.5. Statistical analysis

Continuous variables were shown as means and SD or medians and interquartile ranges (IQRs); categorical data were presented as proportions (number and percentage). Continuous or categorical data were transformed to factors with a binary score. Continuous variables were compared between patients with and without delirium by using *t* test or Wilcoxon test. The *t* test was used if the data were normally distributed in both groups; the Wilcoxon test was used if normality was violated. Categorical variables were compared using χ^2 test (Pearson χ^2 test) or the Fisher exact test. If sample sizes in each category were large enough, the χ^2 test was used; otherwise, the Fisher exact test was used. Ranked variables were compared using Wilcoxon test. To examine the impact of various factors on the development of delirium, we used univariate and then multivariate step logistic regression analysis. Factors for which the *P* value < .3 were entered into multivariate models. The *P* values for entry and removal were .05 and .10, respectively. $P < .05$ was considered statistically significant. All statistics were calculated with SAS, version 9.3. The variables included in multivariate analysis are presented in Table 2.

3. Results

During the 8-month study interval, 256 CABG patients were admitted to the ICU; 249 (97%) were enrolled in the cohort, and 7 (3%) met exclusion criteria. Exclusions included 7 patients, in which 5 cases had incomplete data collection, and 2 patients did not wake up after surgery. Of the 249 patients enrolled in this study, 78% (197/249) were men. The mean age was 62.90 years (SD, 9.41; range, 20-84). Sixty-nine percent received education of middle school or above. Most of the patients (81%) had CABG only, and the rest (19%) received another operation simultaneously, including cardiac valve replacement, aortic repair, and lobectomy of lung.

In all patients, delirium was indicated in 76 cases (30.52%) (32% of male patients, 23% of female patients, 41% of patients ≥65 years old, and 22% of patients <65 years old).

Of the 49 risk factors surveyed on the checklist, the independent *t* test, Wilcoxon test, or χ^2 analysis indicated that 34 factors were more prevalent in the patients who had delirium ($P < .05$). Among the preoperative variables, older age, hearing or language barrier, predisposing cerebral disease, predisposing cardiac surgery, renal dysfunction, poor NYHA heart function anxiety, and low MRS had a higher risk of developing delirium. Atrial fibrillation, elevated EuroSCORE, and cognitive impairment were significant risk factors for delirium; moreover, these factors show a higher risk after multivariate analysis (ORs were 3.975, 1.178, and 3.231, respectively). Intraoperative factors that were more prevalent in delirium were surgery type, surgery duration, and hypoxia; whereas, emergency operation, CPB use, number of distal anastomoses, and blood transfusion volume greater than 1 L were not risks in the studied cohort. Postoperative precipitating factors that were more prevalent in patients with delirium were blood transfusion volume greater than 1 L, sedation or analgesia treatment, type and duration of inotropic medications, duration of mechanic ventilation, higher creatinine, AF, low cardiac output, hypoxia, later mobilization, treatment with diuresis, hypercarbia, postoperative complications, system involved in complications, and reoperation for bleeding and acute infection. Patients with poor quality of sleep and electrolyte disturbance had a higher risk of developing delirium than patients without these situations, even after multivariate analysis (ORs, 5.001 and 2.095, separately). The results of the univariate analysis of all 49 preoperative, intraoperative, and postoperative variables are shown in Table 1.

Table 3
Outcomes of patients with delirium or not after CABG

Outcomes	With delirium (n = 76)	No delirium (n = 173)	*P*
Length of stay			
ICU days, median (IQRs)	4.5 (3.6)	2 (1.3)	<.0001
Postoperative hospital days, median (IQRs)	12 (10.20)	10 (8.12)	<.0001
Hospital days, median (IQRs)	21 (16.30)	17 (14.19)	<.0001
Hospital expense (Ren Min Bi), median (IQRs)	94187 (73631, 118628)	70938 (61600, 79658)	<.0001
ICU mortality, n (%)	5 (7%)	4 (2%)	.1127

The variables that were significantly more prevalent in delirious patients than nondelirious patients were incorporated into a stepwise logistic regression analysis. According to the statistical data, the best regression model contained 3 preoperative factors, 1 intraoperative factor and 2 postoperative factors ($P < .05$, Table 2). Specifically, patients with preoperative AF, elevated EuroSCORE and cognitive impairment, prolonged surgery duration, postoperative poor quality of sleep, and electrolyte disturbance were 3.957, 1.178, 3.231, 1.008, 5.001, and 2.095 times, respectively, more likely to have postoperative delirium than patients without these conditions after CABG.

Patients with postoperative delirium had a longer length of ICU stay (4.5 vs 2 days), postoperative hospital stay (12 vs 10 days), and hospital stay (21 vs 14 days) as well as higher hospital expense compared with patients who did not develop delirium (Table 3).

4. Discussion

This study is the first report to clarify the incidence and risk factors of delirium in a single sample of patients after CABG in a large ICU setting in China. The incidence of delirium was 30.52%, which is in the range of the previously reported incidence of postoperative delirium after CABG [2,4,16,17]. Delirium was associated with adverse outcomes in this study. The median ICU, postoperative hospital, and hospital length of stay were approximately 2.5, 2, and 4 days longer for patients with delirium, respectively. Obviously, postoperative delirium is a serious, frequent complication in patients after CABG in ICU, which deserves attention.

Preventing delirium by identifying and modifying risk factors is the best intervention. We examined 49 likely perioperative risk factors of delirium in our study. Ultimately, there were 34 factors that were more prevalent in patients with delirium than in patients without delirium ($P < .05$). To determine the predictive risk factors for postoperative delirium, we used logistic regression analysis to analyze 41variables that had *P* values < .3 between the delirious and nondelirious groups. Our study showed that preoperative AF, elevated EuroSCORE, cognitive impairment, surgery duration, postoperative poor quality of sleep, and electrolyte disturbance were the independent predictors of postoperative delirium.

In our study, preoperative diagnosis AF patients were given medical treatment according to the presentation of the arrhythmia, such as antithrombotic therapy, control ventricular rate, and cardioversion. However, AF was still one of the strongest independent predictors of postoperative delirium, with an odds ratio (OR) of 3.957 (95% confidence interval [CI], 1.727-9.066) according to our data. Delirium was present in 62% (26/42) of patients with preoperative AF. The same result was found by previous studies [18-20]. The underlying cause was that AF could develop emboli and reduce cerebral perfusion by decreasing cardiac output [18]. The result of the study increases practical awareness that patients with preoperative diagnosis AF have an increased risk of delirium, and special attention should be paid to them.

Currently, advances in anesthesia, CPB, and surgical practice allow surgery to be performed on patients with high surgical risk. The EuroSCORE is the most popular preoperative risk score in cardiac surgery, which was created in 1999 and was used as the predictor of short-term mortality of the patients after heart operations [11]. Furthermore, EuroSCORE plays a crucial role in the development of postoperative delirium [21-24]. Similar to a previous study, we confirmed that patients with elevated EuroSCOREs had a significantly greater tendency for postoperative delirium with an odds of 1.178 (95% CI, 1.018-1.364). Of the 47 patients with a EuroSCORE higher than 4, 53% (25 cases) developed postoperative delirium, and the incidence was more than half.

Among EuroSCORE assessment, 3 groups of risk factors were identified: patient-related factors including advanced age, cardiac-related factors, and operation-related factors. In our study, mean age was 64.71 ± 9.95 and 62.10 ± 9.08 years in the delirious and nondelirious groups ($P = .0441$), respectively, demonstrating that advanced age is one of the risk factors for delirium, which supports many previous studies [25,26]. Aging is associated with more advanced cerebral atherosclerosis, which narrows the cerebral vessels and inhibits blood flow, in addition to postsurgical inflammatory response and postoperative hypotension or hypoxemia, which increases the risk of cerebral hypoperfusion. In addition, age is not only a chronological process but also comprises many complicated or combined medical conditions that might facilitate the onset of postoperative neurologic complications. There is a close correlation between delirium and the severity of illness; the incidence of delirium increases with the severity of the illness. Illness severity can be displayed by elevated EuroSCOREs in CABG patients [23,27]. We recommend screening newly admitted CABG patients to detect those who are vulnerable.

The impact of cognitive impairment on poor postoperative neurologic outcomes has been analyzed and proven by previous investigators [5,21,28]. In our study, in addition to preoperative AF and elevated EuroSCOREs, a strong preoperative predictor of delirium was cognitive impairment (OR, 3.231; 95% CI, 1.008-10.356). Cognitive impairment with MMSE less than 27 was associated with a 3.2-fold increased risk of delirium. We also found that patients with delirium after CABG had a significantly higher prevalence of anxiety than the nondelirious group. A possible explanation for this finding was that higher anxiety patients indicated inadequate psychologic preparation before surgery and had difficulty cooperating after surgery. Indeed, surgical patients with better psychologic preparation had a lower prevalence of postoperative delirium than patients with lower anxiety.

Among the intraoperative risk factors observed, longer surgery time was found to be a strong independent predictor of delirium after CABG, with an OR of 1.008 (95% CI, 1.003-1.014). These findings suggest that delirium tends to occur more often with more complex surgical procedures. Research by Mu et al [4] revealed that every hour of increased surgery time resulted in a 36% increase (OR, 1.360; 95% CI, 1.01-1.83) in the odds risk of delirium. Longer duration of surgery time was not only due to complex procedures but also large doses of anesthetic medicine and greater volumes of blood transfusion, with increased exposure to hypoperfusion and systemic inflammatory response. These factors can cause postoperative complications, including electrolyte disturbance, another independent risk factor of delirium according to our study. Although surgery duration cannot modify in some way, our results highlight the importance of maintaining adequate blood flow during surgery.

Among electrolyte disturbances, hypokalemia, hyperkalemia, hyponatremia, hypernatremia, hypocalcemia, and hypomagnesemia frequently occur after heart operations, as they are closely related to heart function. The impact of electrolyte disturbance on poor neurologic outcomes was analyzed by Fineberg et al [29] in his study on postoperative delirium after lumbar surgery. Our research, which focused on CABG patients, found a similar effect. Of the 141 cases with postoperative electrolyte disturbance, 56 cases developed delirium (40%). Electrolyte disturbance was not only 1.5 times more frequent in the delirium group but also appeared to be an independent predictor of postoperative delirium, with an (OR, 2.095; 95% CI, 1.041-4.216). Currently, ICU staff values the problem of electrolyte disturbance after CABG but

always lags in its management. Further study is needed to determine which electrolyte disturbance results in delirium.

In our study, poor quality of sleep, represented by symptoms of sleep disorder or sleep deprivation appeared to be an independent predictor of postoperative delirium in multivariate analysis, with an OR of 5.001 (95% CI, 2.476-10.101); it was the strongest independent predictor. Of the 57 cases with poor quality of sleep, 36 cases developed delirium. The incidence was high (63%). Sleep disorders and sleep deprivation have been proven to be substantial problems in the ICU [30], a place that is characterized by frequent interruptions, including continuous alarms, lights, ventilator dyssynchrony, and treatment-related interruptions. Poor quality of sleep was previously associated with delirium in ICU patients [31]. In the study by Mattoo et al [32], 80% of delirium patients had a moderate or severe sleep disorder, and the incidence was higher among elderly patients. However, the relationship between poor sleep and delirium remains unknown. In addition, authors have been uncertain that poor quality of sleep is a risk factor or outcome of delirium [33,34]. If poor sleep occurs, a consultation with an ICU physician might be indicated to initiate appropriate therapy, thereby improving clinical outcomes, including decreasing the incidence of delirium development [35]. Nonpharmacologic interventions could also be used to improve sleep quality. A study by Van Rompaey et al [15] showed that the use of earplugs during the night could decrease the incidence of confusion for ICU patients and postpone confusion development. Minimizing care-related interruptions during the night should be implemented as a part of a delirium intervention program.

Delirium was attributed to various medical problems, as the study indicated. Unfortunately, some of underlying causes cannot be corrected. As the prevention and the treatment of delirium are multifaceted, environment control and behavioral modifications should be implemented, in addition to delirium assessment, cause identification, and pharmacologic treatment. In the ICU setting, it is possible to overcome sensory overload or deprivation; orient the patients frequently; create a calm, comfortable environment; encourage normal sleep-wake rhythm by opening blinds and encouraging wakefulness and mobility during daytime; and allow the patients an uninterrupted period of sleep at night with low levels of noise and light, especially in a large ICU setting similar to the ICU in this study.

4.1. Study limitations

We focused on delirium in the early postoperative period during patients' stays in the ICU for a maximum of 7 days or until ICU discharge. Therefore, delirium that was developed on a general ward may have been missed. In addition, due to the relatively short observation period, our statistical analysis might be limited due to small sample size in the delirium group and requires validation in larger groups. Another limitation of the present study was that it was conducted in a single cardiovascular ICU, and some risk factors may have not been included in our data analysis. Because of these limitations, the results of the study should not be generalized to other CABG patients.

5. Conclusions

Delirium is a temporary mental disorder that is characterized by abnormal arousal, language and cognition, perception, orientation, mood, sleeping patterns, and neurologic functioning in the context of a medical etiology [19]. Our data concur with the findings of many authors who have demonstrated that increased ICU stay, prolonged hospital stay, and higher care costs occur in patients who experience delirium. All of the serious consequences indicated that delirium is one of the most dangerous complications after CABG.

Delirium is a complex phenomenon, and screening for delirium will improve its detection. As the patients undergoing CABG will be on a ventilator during the early postoperative period, we chose the CAM-ICU as the validated instrument, which can be used in people with mechanical ventilation [36,37].

Delirium is strongly associated with factors that are already present as baseline conditions, such as advanced age, sex, and diminished cardiac function. Most conditions are unchangeable. However, they can increase practical awareness that patients with these characteristics have an increased risk of delirium. Delirium is also strongly affected by risk factors that develop during hospitalization, such as electrolyte disturbance, hypoxia, and hypotension. These factors are triggers that cause delirium, but most can be prevented. To decrease the incidence of delirium, we explored the risk factors of delirium prospectively in the first step. The study analyzed potential preoperative, intraoperative, and postoperative risk factors of delirium. Six perioperative factors, preoperative AF, cognitive impairment, high EuroSCORE, long surgery duration, postoperative poor quality of sleep, and electrolyte disturbance were significant independent predictors of postoperative delirium after CABG. The results of this study can serve as the basis for developing a checklist of 34 prevalent perioperative risk factors for delirium, with special attention to the 6 predictive factors. Therefore, we recommend applying interventions to these patients.

This study clarified the extent of delirium incidence among our patients who underwent CABG in a large ICU setting and increased practical considerations of delirium interventions. Delirium is an important problem to solve. Therefore, CAM-ICU assessments are now performed regularly in our daily nursing care to identify susceptible patients and intervene early.

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