Risk factors for postoperative delirium in patients with cardiac surgery

Min-Song Kim[1] and Sang-Hee Kim[2] (iD)

[1]Yeungnam University Medical Center, Daegu, Republic of Korea
[2]College of Nursing, Keimyung University, Daegu, Republic of Korea

Abstract

Purpose: Patients admitted to the intensive care unit (ICU) after cardiac surgery are at high risk of delirium due to a variety of factors. This study aimed to identify the incidence of postoperative delirium in adult patients with cardiac surgery and its risk factors, such as characteristics of subjects, disease and treatment-related, as well as nursing-related characteristics. **Methods:** The study was performed on adult patients who underwent cardiac surgery at Y University Hospital in D city; a total of 195 patients met the inclusion criteria. **Results:** The results of this study determined that 67 of 195 adult cardiac surgery patients had postoperative delirium, 53.7% of which occurred in the ICU and 46.3% in the general ward. Risk factors of postoperative delirium were postoperative symptoms of inflammation (odds ratio [OR] = 10.18, $p = 0.002$), continuous renal replacement therapy application after surgery (OR = 9.05, $p = 0.006$), postoperative sleep disorder (OR = 8.98, $p < 0.001$), age (OR = 6.23, $p = 0.006$), length of stay in the ICU (OR = 3.83, $p = 0.031$), history of stroke (OR = 3.71, $p = 0.033$), the number of postoperative catheter retention (OR = 1.53, $p = 0.065$), Acute Physiology and Chronic Health Evaluation II score (OR = 1.12, $p = 0.006$), and time of operation (OR = 1.01, $p = 0.042$). **Conclusion:** This study confirmed that after cardiac surgery, postoperative delirium occurred in patients during their ICU stay and after their transfer to a general ward. Considering that after cardiac surgery ICU-related factors affect the incidence of delirium in the general ward, there is a need for continuous monitoring of ICU-related factors after the patient gets transferred to a general ward.

Keywords

Cardiac surgery, delirium, risk factors

Corresponding author:
Sang-Hee Kim, N525, College of Nursing, Keimyung University, 1095 Dalgubuldaero, Dalseo-gu, Daegu 42601, Republic of Korea.
Email: shkim07@gw.kmu.ac.kr

Introduction

The World Health Organization listed heart disease as the leading cause of death in 2022;[1] the number of Korean adults undergoing surgery for acquired heart disease is also rising.[2] Cardiac surgery is a complex and high-risk procedure that requires post-operative ventilator treatment, intensive observation in the intensive care unit (ICU), and transfer to a general ward when the condition improves.[3] Patients admitted to the ICU after surgery are at high risk of delirium due to various factors, such as drainage tubes and monitors attached to their bodies, movement restrictions and pain caused by ventilator application, day and night indistinguishable lighting, noise, and psychological anxiety.[4] Such treatment and environmental factors in the ICU impact the occurrence of delirium in both the ICU and general ward.[5]

Delirium is a clinical syndrome characterized by a short-term lack of attention, poor concentration, sudden changes in consciousness, and decreased persistence; it is accompanied by various symptoms such as decreased reality and distorted cognition, illusion, and hallucination.[4] In a previous study, delirium occurred in 11–14% of hospitalized patients in the general ward and 34–50% of ICU patients,[6] and the incidence of delirium after cardiac surgery was 43–55%.[7,8] The occurrence of delirium after cardiac surgery negatively impacts the prognosis and recovery of patients. Aggressive behavioral patterns and excessive excitement and sleep disorder by delirium delay ventilator departure after surgery, which increase both ICU and hospital stays and decrease treatment compliance; this leads to increased complications and mortality.[9] Additionally, the occurrence of delirium after cardiac surgery affects the patient's long-term cognitive function, increases the probability of hospital readmission after discharge, and reduces the quality of life.[10]

Delirium can be recovered when the triggering factor is removed; hence, early detection and intervention through the identification of risk factors can prevent its occurrence in patients and improve its prognosis.[4] In addition, the delirium management guidelines recommend a higher level of nonpharmaceutical intervention to alleviate delirium symptoms than drug administration therapy after delirium occurs.[11] Managing delirium in patients is crucial and requires early identification of risk factors, prevention, and timely intervention; however, in a busy work environment, the importance of nursing for patients with severe disease and delirium management may be overlooked.[12] Considering that the unresolved risk factors in the ICU may influence the occurrence of delirium after transferring to the general ward after 2–3 days in the ICU, it is important to continuously monitor the associated factors for delirium management in the ICU even after transfer to the general wards.[9]

Delirium is not caused by a single factor but rather results from the interaction of various factors.[6] Patient age, preoperative alcohol consumption, and smoking are associated with postoperative delirium.[6,13] Fasting time, sedative administration time, disease severity, ICU stay and ventilator application period, and application of continuous renal replacement therapy (CRRT) are factors that affect the occurrence of delirium.[4,14,15] In addition to the disease-related factors identified as risk factors for delirium in cardiac surgery patients, various complex risk factors associated with patients need to be analyzed, including factors such as nursing needs, postoperative sleep disturbances, bedsores, and catheter number.[6,7,16]

Delirium occurrence after overseas cardiac surgery is 13.3–17.5% in ICU and 39–50% in general wards, suggesting that delirium occurs even after moving patients from ICU to general wards after surgery.[6,9] Considering the current trend where cardiac surgery patients spend less time in the ICU and more time in general wards,[17] it is necessary to assess the continuity and sustainability of the occurrence of delirium after surgery in both ICU and the general wards.[9] Accordingly, this study expanded the scope of adult cardiac surgery patients beyond the postoperative ICU admission period to determine the timing and extent of delirium occurrence and identified the risk factors that impact the occurrence of delirium; thus, we can provide basic data for the development of nursing interventions for delirium management.

Methods

Research design and subjects

This is a retrospective research study to identify the timing and extent of delirium occurrence after surgery in adult patients undergoing cardiac surgery and to identify the risk factors for delirium occurrence. This study included a total of 195 subjects who met the selection criteria, excluding 167 who met the exclusion criteria, out of 362 subjects who underwent heart surgery at Yeungnam University Hospital during the period from January 2020 to June 2021. The specific selection criteria for study subjects were adult patients over the age of 18 who had cardiac surgery, patients who did not develop delirium before cardiac surgery, patients without cognitive impairment, and patients who were able to physically act. The specific exclusion criteria for participants in this study are patients with a history of neurological treatment due to neurological problems caused by brain lesions after heart surgery, patients diagnosed with neuropsychiatric diseases and dementia before heart surgery or taking related drugs, and patients who reentered the ICU during the post-heart surgery investigation period. The sample size of this study was calculated as a two-sided test for logistic regression using the G-power 3.19 program, 19 predictors, .85 power, and .05 significance level, and the minimum sample size was 178 people based on the above criteria.

Research tool

Delirium. In this study, based on the Nursing Delirium Screening Scale (Nu-DESC) developed by Gaudreau et al., delirium was evaluated with the approval of the original author and translator[18] and the Korean Nu-DESC, which was modified by Kim et al. to suit the Korean situation.[19] The tool consists of five questions: decreased persistence, inappropriate behavior, inappropriate conversations, auditory hallucinations, and psychotropic delay items, which are screened as delirium when they score 2 or more out of 5 points in total. The tool has a sensitivity of .85 and a specificity of .73 when calculated based on a psychiatrist's delirium diagnosis. This is similar to the sensitivity .77–.89, and specificity .72–.75 of the most widely used delirium analysis tool Confusion Assessment Method for the ICU.[19]

Characteristics of the subjects' delirium generation. Disease and treatment-related characteristics were investigated for comorbid diseases, type of surgery, operation time, postoperative pain, postoperative inflammatory reactions, postoperative nothing per os (NPO) time, postoperative time to use sedatives, Acute Physiology and Chronic Health Evaluation II (APACHE II) score,[20] length of ICU stay, ventilator application period, CRRT application, postoperative demand of nursing, sleep disorders, postoperative pressure ulcer, and the number of catheters. The postoperative nursing demands of the patient were investigated by categorizing them into four groups based on the total score measured by the Korean Patient Classification System ICU after surgery.[21]

Data collection

This study received approval for data collection from the Institutional Review Board of Yeungnam University Hospital (YUMC202112046-HE001). This study is a retrospective investigation study, which was exempted from the requirements for written or oral consent of the subject from the institutional review committee; the researcher checked the subject's medical records and collected data. The identification information of the study subjects was managed by assigning an arbitrary study subject number, and all related documents were encrypted and stored in a researcher's private space with a double stash device so that only the researcher could access it. In this study, the delirium screening period was based on previous studies, and the average hospital stay after cardiac surgery was 8 days, and the occurrence of delirium was investigated for 10 days after cardiac surgery, considering that delirium occurred from 2 to 6 days after surgery.[3,5,22] Patients who had delirium at least once were classified as the delirium group, and those who had never had delirium were classified as the nondelirium group. To confirm the reliability between evaluators, the degree of agreement between one nurse with more than 5 years of clinical experience and a sample of 25 out of the 195 subjects was analyzed using percentage agreement and Kappa values. As a result of analyzing the degree of agreement between investigators, the percentage of agreement was 96.0%, and the Kappa value was confirmed to be .91.

Analysis method

Data collected in this study were analyzed by setting the significance level below .05 using the IBM SPSS ver. 25.0 (IBM Corp., Armonk, NY, USA). The general characteristics, disease, and treatment-related characteristics of the subjects were demonstrated by real numbers and percentages, mean, and standard deviation. Postoperative delirium incidence and delirium patterns of patients were presented by real numbers, percentages, mean, and standard deviation. The difference in characteristics according to the presence or absence of delirium was analyzed by independent *t*-test and chi-square test. Risk factors for the development of postoperative delirium were analyzed using logistic regression analysis, with variables with statistically significant differences between the delirium and nondelirium groups as independent variables and the presence or absence of delirium as the dependent variable.

Results

Patient characteristics

The mean age of the 195 subjects in this study was 66.56 ± 11.31 years: 145 (74.4%) of them were male and 50 (25.6%) were female. A total of 119 (61.0%) of the subjects were accompanied by high blood pressure, and coronary artery bypass surgery was the most common in 107 subjects (54.9%). The average operation time was 5.97 ± 1.39 h, and the NPO time after surgery was 28.53 ± 12.58 h. Patients' postoperative sedative use time averaged 24.89 ± 22.43 h, APACHE II score averaged 17.19 ± 5.98 points, mean length of ICU stay was 2.33 ± 1.87 days, ventilator application period was 1.33 ± 0.92 days, and 22 subjects (11.3%) applied CRRT. Patient's postoperative demand for nursing was the highest with 116 (59.5%) critically ill patients in group 3. There were 161 (82.6%) patients who did not have sleep disorders after cardiac surgery, and 142 (72.8%) subjects who did not develop pressure ulcers. The average number of catheters after cardiac surgery was 8.57 ± 0.96 (Table 1).

Incidence and symptoms of delirium after cardiac surgery

As a result of checking the degree of delirium occurrence after heart surgery, 67 (34.4%) of the total 195 patients had delirium. According to an analysis of 67 patients (34.4%) who had delirium after cardiac surgery, 36 (53.7%) had delirium in the ICU, and 31 (46.3%) in the general ward. In terms of the patient's delirium pattern, inappropriate communication was the most common with 60 (30.8%), followed by inappropriate behavior with 53 (27.2%), disorientation with 36 (18.5%), illusions/hallucinations with 20 (10.3%), and psychomotor retardation with 12 (6.2%) (Table 2).

Comparison of characteristic differences between delirium and nondelirium groups

There were significant differences in age, preoperative stroke comorbidities, surgery type, postoperative inflammatory response, postoperative fasting time, sedative administration time, APACHE II score, length of stay in the ICU, ventilator application period, and CRRT application. The average age of the delirium group was 7.6 years, which was higher than that of the nondelirium group ($t = 4.66$, $p < 0.001$), many patients had preoperative strokes ($\chi^2 = 5.96$, $p = 0.015$), and two or more surgeries were performed at the same time ($\chi^2 = 16.08$, $p = 0.001$). In addition, compared to the nondelirium group, the delirium group has an average operation time ($t = 2.60$, $p = 0.010$) and NPO time ($t = 3.99$, $p < 0.001$), time to use sedatives ($t = 3.77$, $p < 0.001$), length of ICU stay ($t = 5.37$, $p < 0.001$), and the ventilator application period was long ($t = 3.77$, $p < 0.001$). The delirium group, rather than the nondelirium group, had a postoperative inflammatory response ($\chi^2 = 20.25$, $p < 0.001$), and there were many applications of postoperative CRRT ($\chi^2 = 24.77$, $p < 0.001$); the APACHE II score indicating the severity of the disease was high ($t = 4.58$, $p < 0.001$). On the other hand, the nondelirium group had a lower need for postoperative demand of nursing ($\chi^2 = 13.20$, $p = 0.001$), postoperative sleep disorders

Table 1. Patient characteristics (*n* = 195).

Characteristic	Data	Mean ± SD
Gender		
Men	145 (74.4)	
Women	50 (25.6)	
Age (years)		66.56 ± 11.31
<60	50 (25.6)	
60–69	63 (32.3)	
≥70	82 (42.1)	
Alcohol drinking		
Yes	81 (41.5)	
No	114 (58.5)	
Smoking		
Yes	82 (42.1)	
No	113 (57.9)	
Disease and treatment-related comorbidity†		
Hypertension	119 (61.0)	
Diabetes mellitus	85 (43.6)	
Hyperlipidemia	41 (21.0)	
CVA	25 (12.8)	
Atrial fibrillation	11 (5.6)	
CRF	15 (7.7)	
Type of surgery		
CABG	107 (54.9)	
Valve surgery	37 (18.9)	
Aortic aneurysm	4 (2.1)	
Complex surgery	47 (24.1)	
Operation time (hour)		5.97 ± 1.39
>7	41 (21.0)	
5–7	111 (56.9)	
<5	43 (22.1)	
Postoperative pain		
Yes	56 (28.7)	
No	139 (71.3)	
Postoperative inflammatory		
Yes	22 (11.3)	
No	173 (88.7)	
Postoperative NPO time (hour)		28.53 ± 12.58
>48	12 (6.2)	
24–48	91 (46.6)	
<24	92 (47.2)	
Time to use sedatives (hour)		24.89 ± 22.43
>24	50 (25.6)	
12–24	130 (66.7)	
<12	15 (7.7)	
APACHE II score (0–71)		17.19 ± 5.98
ICU length of stay (day)		2.33 ± 1.87
≥5	20 (10.2)	
2–4	99 (50.8)	

(Continued)

Table 1. (continued)

Characteristic	Data	Mean ± SD
<2	76 (39.0)	
Use of ventilator (day)		1.33 ± 0.92
≥24	4 (2.1)	
12–24	35 (17.9)	
<12	156 (80.0)	
CRRT		
Yes	22 (11.3)	
No	173 (88.7)	
Nursing-related KPCS-ICU		
≤2 division	46 (23.6)	
3 division	116 (59.5)	
4 division	33 (16.9)	
Postoperative sleep disorder		
Yes	34 (17.4)	
No	161 (82.6)	
Postoperative pressure ulcer		
Yes	53 (27.2)	
No	142 (72.8)	
Number of catheters		8.57 ± 0.96

Data are presented as number (%) or mean ± standard deviation.
APACHE, Acute Physiology and Chronic Health Evaluation; CABG, coronary artery bypass graft; CRF, chronic renal failure CRRT, continuous renal replacement therapy; CVA, cerebrovascular accident; ICU, intensive care unit; NPO, nothing per oral; KPCS-ICU, Korean Patient Classification System-Intensive Care Unit.
†Multiple response.

($\chi^2 = 8.46$, $p = 0.004$), and a lower number of catheters (t = 2.64, $p = 0.009$) than the group with delirium (Table 3).

Risk factors for delirium occurrence

To identify the risk factors for the subjects for developing delirium after surgery, a logistic regression analysis was performed using variables that showed significant differences between the delirium and nondelirium groups as independent variables and the presence or absence of delirium as the dependent variable. As a result of performing the Hosmer–Lemeshow model fit test, the goodness-of-fit of the regression model was significant ($\chi^2 = 9.88$, $p = 0.274$), and Cox & Snell's coefficient of determination ($R^2 = .42$), which indicates the explanatory power of the model, showed 42% explanatory power, Nagelkerke's coefficient of determination ($R^2 = .58$) showed an explanatory power of 58%.

As a result of the analysis, those aged 70 or older had 6.23 times (95% confidence interval [CI] = 1.70–22.84, $p = 0.006$) higher delirium incidence rate than those under 60, the postoperative inflammatory response is 10.18 times (95% CI = 2.39–43.31, $p = 0.002$), the application of postoperative CRRT is 9.05 times (95% CI = 1.90–43.21, $p = 0.006$), subjects with length of ICU stay between 2 and 4 days had 3.83 times (95% CI = 1.13–12.97, $p = 0.031$) higher risk of delirium occurrence than those

Table 2. Incidence and symptoms of delirium after cardiac surgery (N = 67).

Characteristic	Data	Mean ± SD
Delirium		
Yes	67 (34.4)	
No	128 (65.6)	
Pattern of delirium†		
Disorientation	36 (18.5)	
Inappropriate behavior	53 (27.2)	
Inappropriate communication	60 (30.8)	
Illusions/Hallucinations	20 (10.3)	
Illusions/Hallucinations	12 (6.2)	
Delirium (yes)		
Place of occurrence		
ICU	36 (53.7)	
General ward	31 (46.3)	
Time of occurrence (day)		
POD 2	34 (50.7)	
POD 3–4	22 (32.8)	
POD ≥5	11 (16.4)	
Duration of delirium (day)		3.79 ± 2.53

Data are presented as number (%) or mean ± standard deviation.
ICU, intensive care unit; POD, postoperative day.
†Multiple response.

with a stay of fewer than 2 days. Patients with a history of stroke had 3.71 times (95% CI = 1.12–12.33, $p = 0.033$), higher risk of delirium after surgery a higher APACHE II score had 1.12 times (95% CI = 1.03–1.21, $p = 0.006$) higher risk of delirium, and a 1.01 times higher risk of delirium with a longer operating time (95% CI = 1.00–1.01, $p = 0.042$). Subjects' postoperative sleep disorder increased the risk of delirium by 8.98 times (95% CI = 2.91–27.76, $p < 0.001$) and also increased the risk of delirium by 1.53 times (95% CI = 2.91–27.76, $p < 0.001$) as the number of postoperative catheters increased (Table 4).

Discussion

This study was conducted to provide basic data on the development of nursing interventions for delirium management by identifying the timing and extent of delirium occurrence after surgery in adult patients who underwent cardiac surgery and identifying the risk factors that impact delirium occurrence.

In this study, the occurrence of delirium was 34.4%, similar to or different from 15% to 50% of previous studies.[7,9,23] This may be due to the difference in the delirium evaluation period after surgery. In this study, among all patients who developed delirium, 53.7% experienced it in the ICU, and 46.3% experienced delirium after moving to a general ward, showing that postoperative delirium occurs not only in the ICU but also after moving to a general ward. This suggests that it is crucial to prepare a nursing

Table 3. Comparison of characteristic differences between delirium and nondelirium groups (n = 195).

Characteristic	Delirium (n = 67)	Nondelirium (n = 128)	χ^2 or t	p-value
Gender				
Men	47 (32.4)	98 (67.6)	0.95	0.330
Women	20 (40.0)	30 (60.0)		
Age (year)			20.17	
<60	6 (12.0)	44 (88.0)		
60–69	20 (31.7)	43 (68.3)		
≥70	41 (50.0)	41 (50.0)		
	71.52 ± 9.87	63.97 ± 11.18	4.66	
Alcohol drinking				
Yes	29 (35.8)	52 (64.2)	0.13	0.721
No	38 (33.3)	76 (66.7)		
Smoking				
Yes	25 (30.5)	57 (69.5)	0.94	0.332
No	42 (37.2)	71 (62.8)		
Comorbidity†				
Hypertension	43 (36.1)	76 (63.9)	0.43	0.514
Diabetes mellitus	31 (36.5)	54 (63.5)	0.30	0.585
Hyperlipidemia	10 (24.4)	31 (75.6)	2.29	0.130
CVA	14 (56.0)	11 (44.0)	5.96	0.015
Atrial fibrillation	6 (54.5)	5 (45.5)	2.11	0.147
CRF	9 (60.0)	6 (40.0)	4.74	0.130
Type of surgery				
CABG	26 (24.3)	81 (75.7)	16.08	0.001
Valve surgery	13 (35.1)	24 (64.9)		
Aortic aneurysm	1 (25.0)	3 (75.0)		
Complex surgery	27 (57.4)	20 (42.6)		
Operation time (hour)				
>7	20 (48.8)	21 (51.2)	55.43	0.066
5–7	36 (32.4)	75 (67.6)		
<5	11 (25.6)	32 (74.4)		
	6.32 ± 1.51	5.78 ± 1.29	2.60	0.010
Postoperative pain				
Yes	21 (37.5)	35 (62.5)	0.34	0.558
No	46 (33.1)	93 (66.9)		
Postoperative inflammatory				
Yes	17 (77.3)	5 (22.7)	20.25	<0.001
No	50 (28.9)	123 (71.1)		
Postoperative NPO time (hour)				
>48	7 (58.3)	5 (41.7)	11.40	0.003
24–48	39 (42.9)	52 (57.1)		
<24	21 (22.8)	71 (77.2)		
	33.31 ± 15.13	26.02 ± 10.23		
Time to use sedatives (hour)				
≥24	31 (62.0)	19 (38.0)	22.95	<0.001
12–24	33 (25.4)	97 (74.6)		
<12	3 (20.0)	12 (80.0)		
	34.45 ± 29.58	19.89 ± 15.50	3.77	<0.001

(Continued)

Table 3. (continued)

Characteristic	Delirium (n = 67)	Nondelirium (n = 128)	χ^2 or t	p-value
APACHE II score (0–71)	19.78 ± 5.25	15.84 ± 5.92	4.58	<0.001
ICU length of stay (day)				
≥5	35 (68.6)	16 (31.4)	38.91	<0.001
2–4	20 (29.4)	48 (70.6)		
<2	12 (15.8)	64 (84.2)		
	3.42 ± 2.38	1.76 ± 1.21	5.37	<0.001
Use of ventilator (day)				
≥5	13 (76.5)	4 (23.5)	22.00	<0.001
2–4	12 (54.5)	10 (45.5)		
<2	42 (26.9)	114 (73.1)		
	1.73 ± 1.26	1.12 ± 0.57	3.77	<0.001
CRRT				
Yes	18 (81.8)	4 (18.2)	24.77	<0.001
No	49 (28.3)	124 (71.7)		
KPCS-ICU				
≤2 division	6 (13.0)	40 (87.0)	13.20	0.001
3 division	45 (38.8)	71 (61.2)		
4 division	16 (48.5)	17 (51.5)		
Postoperative sleep disorder				
Yes	19 (55.9)	15 (44.1)	8.46	0.004
No	48 (29.8)	113 (70.2)		
Postoperative pressure ulcer				
Yes	20 (37.7)	33 (62.3)	0.37	0.544
No	47 (33.1)	95 (66.9)		
Number of catheters	8.82 ± 1.00	8.45 ± 0.91	2.64	0.009

Data are presented as number (%) or mean ± standard deviation.
APACHE, Acute Physiology and Chronic Health Evaluation; CABG, coronary artery bypass graft; CRF, chronic renal failure CRRT, continuous renal replacement therapy; CVA, cerebrovascular accident; ICU, intensive care unit; NPO, nothing per oral; KPCS-ICU, Korean Patient Classification System-Intensive Care Unit.
†Multiple response.

strategy for careful observation and prevention of delirium occurrence even after the patients move from the ICU to the general ward after cardiac surgery.

Age is identified as a risk factor for delirium occurrence and a history of stroke is highly related to delirium occurrence in most hospitalized patients, including cardiac surgery patients.[6,7,14] Older patients are more prone to acquire comorbidities due to aging, and the vulnerability to drug toxicity increases due to decreased metabolic function.[13,14] Brain region lesions caused by stroke are reduced in activity of the cholinergic nervous system, resulting in reduced ability to cope with acute stress situations such as surgery.[24] In particular, imbalances in neurotransmitters, such as acetylcholine secretion deficiencies involved in arousal and concentration, increase the risk of delirium development and emphasize the importance of delirium management in the elderly.[6] Therefore, elderly patients over 70 years of age and stroke victims who have undergone imaging

Table 4. Risk factors of delirium after cardiac surgery (*n* = 195).

Characteristic	Category	OR	95% CI		*p*-value
			Lower	Upper	
Postoperative inflammatory	Yes	10.18	2.39	43.31	0.002
CRRT	Yes	9.05	1.90	43.21	0.006
Postoperative sleep disorder	Yes	8.98	2.91	27.76	<0.001
Age (year) (Ref: < 60)	≤70	6.23	1.70	22.84	0.006
ICU length of stay (day) (Ref: < 2)	2~4	3.83	1.13	12.97	0.031
CVA	Yes	3.71	1.12	12.33	0.033
Number of catheters		1.53	0.97	2.40	0.045
APACHE II score		1.12	1.03	1.21	0.006
Operation time (hour)		1.01	1.00	1.01	0.042

OR, odds ratio; CI, confidence interval; APACHE, Acute Physiology and Chronic Health Evaluation; CRRT, continuous renal replacement therapy; CVA, cerebrovascular accident; ICU, intensive care unit.

surgery will be classified as high-risk groups for delirium; efforts for early detection and active delirium prevention activities will be important strategies.

Patients who have undergone cardiac surgery must be treated in the ICU for the application of ventilators and intensive observation after the surgery. However, holding a conduit in the ICU after cardiac surgery, application of CRRT, and length of stay were identified as risk factors for delirium occurrence. Mechanical noise in the ICU and conduit retention and immobility, separation from family cause stress and anxiety in patients, increasing the risk of delirium.[25] However, it should be noted that delirium management may be overlooked due to the nature of the ICU, where nursing care for seriously ill patients takes priority. To manage delirium, nurses classify and manage patients who have been in the ICU for more than two days as a high-risk group; cooperation and efforts among medical staff are required to periodically assess unnecessary catheters and remove them early.

Unlike the findings of Siew et al.,[15] which suggested that the application of postoperative CRRT in the ICU reduces the risk of delirium by removing inflammatory mediators, metabolites, and neurotoxins in patients with kidney injury,[15] this study identified it as a risk factor for delirium occurrence. Discomfort related to immobility and mechanical noise resulting from the application of CRRT after surgery in the ICU may increase the risk of developing delirium.[25] In addition, CRRT can be affected by differences in patient severity and various variables; hence, repeated studies are needed to confirm the association with the occurrence of delirium.

It can be seen that, the longer the patient's surgery time, the higher the risk of delirium due to increased use of anesthetics and surgical-related drugs that affect delirium occurrence.[13,26] Meanwhile, the use of a cardiopulmonary bypass during surgery can cause delirium due to nerve damage caused by a cerebral inflammatory response, as blood inside the body stagnates outside the body through an artificial circuit.[27] Considering

the fact that the use of a heart-lung machine during surgery is necessary due to the nature of cardiac surgery, repeated research is needed to confirm the relationship between the patient's operation time and the time of artificial heart-lung machine use with the occurrence of delirium. The patient's inflammatory response is a risk factor for delirium,[13,28] and this study also found that the risk of delirium after surgery was approximately six times higher. Stimulations such as surgery and infection activate immune cells in the body, causing inflammatory reactions and cerebral inflammation, which lead to nerve damage in the brain and neurotransmission imbalance, thereby increasing the risk of delirium.[29] This suggests that providing nursing activities to prevent infection after cardiac surgery is a crucial strategy for preventing delirium.

The APACHE II score, which represents a patient's disease severity, contains variables related to delirium, such as the Glasgow Coma Scale and age, which can identify a patient's neurological problems as evaluation items. In addition, the higher the severity of the disease, the lower the body's ability to defend against acute stress situations such as surgery, and the higher the risk of delirium.[6,13,30] For this reason, it can be seen that patients with a high APACHE II score are vulnerable to delirium occurrence; this was also identified as a risk factor for delirium occurrence in this study. Early detection and intervention through the identification of delirium risk factors can prevent the occurrence of delirium in patients and improve the prognosis of the disease.[4] Therefore, priority should be given to checking the APACHE II score of cardiac surgery patients after surgery, conducting periodic assessments, and preventive nursing interventions for the occurrence of delirium in patients with high disease severity.

Finally, the subjects' postoperative sleep disorder has been identified as a risk factor for delirium, which is consistent with the results of several previous studies.[16,31] A patient's sleep disorder causes fatigue, anxiety, attention deficit, and poor concentration, thereby increasing the risk of delirium.[6,13] It is important to note that the occurrence of delirium after cardiac surgery affects the patient's prognosis and recovery.[9,26] This suggests that to prevent delirium, the patient's sleep status after cardiac surgery should be closely monitored, and nursing intervention to improve sleep is necessary.

In this study, the degree of delirium after cardiac surgery and the risk factors were analyzed. In addition, ICU-related factors were continuously observed even after the patient moved to the general ward. In clinical practice, it is important to consider ICU-related risk factors and to continue observation and management even after patients are moved to a general ward. This is crucial for managing delirium that occurs after cardiac surgery. Furthermore, based on the results of this study, it will be important to develop and apply an intervention program in clinical practice to prevent delirium occurrence in patients who have undergone cardiac surgery.

Limitations of this Study

This study has the following limitations. First, since this study confirmed the degree of delirium occurrence during the period up to 10 days after surgery, it was not possible to confirm the occurrence of delirium after 10 days. Further research suggests that an expanded study that observes the entire hospital stay period after surgery is needed to accurately confirm the occurrence of delirium. Second, this study is a retrospective

research study, and there is a limitation for not considering environmental factors such as noise and lighting that can affect the occurrence of delirium after surgery.

Conclusion

In this study, the degree and risk factors of delirium occurrence after cardiac surgery were analyzed, and ICU-related factors were continuously observed even after the patient moved to the general ward. To manage delirium in adult cardiac surgery patients, nurses must recognize the importance of continuously observing the risk factors related to delirium in the ICU even after they move to a general ward. Various risk factors for delirium after cardiac surgery have been identified. Based on the results of this study, developing and applying nursing interventions to prevent delirium will be a critical strategy for delirium management.

Authors' contribution

Study conception and design: K-SH. Data collection: K-MS. Data analysis and interpretation: K-SH, K-MS. Drafting of the article: K-SH, K-MS. Critical revision of the article: K-SH.

Ethics approval

For this study's data collection, medical records were collected with approval from the medical information center of the affiliated institution after the Institutional Review Board (IRB) approval (YUMC202112046-HE001).

ORCID iD

Sang-Hee Kim ⓘD https://orcid.org/0000-0001-7331-5247

References

1. World Health Organization. *Global burden of disease projections of mortality and burden of disease [Internet]*. Geneva: WHO, 2022. [update 2022; cited 2024 February 10]. Available from: http://www.who.int/topics/global_burden_of_disease/en/.
2. The Korea Heart Foundation. *Status of heart surgery by year [Internet]*. Seoul: The Korea Heart Foundation, 2022. [update 2021; cited 2023 April 10]. Available from: https:// www.heart.or.kr. https://doi.org/10.21037/apm-21-3954

3. Jiménez Rivera JJ, Llanos Jorge C, López Gude MJ, et al. en representación del GTCICYRCP. Perioperative management in cardiovascular surgery. Manejo perioperatorio en cirugía cardiovascular. *Med Intensiva (Engl Ed)* 2021; 45: 175–183.

4. Mattimore D, Fischl A, Christophides A, et al. Delirium after cardiac surgery—A narrative review. *Brain Sci* 2023; 13: 1682.

5. Greaves D, Psaltis PJ, Davis DHJ, et al. Risk factors for delirium and cognitive decline following coronary artery bypass grafting surgery: a systematic review and meta-analysis. *J Am Heart Assoc* 2020; 9: e017275.

6. Hshieh TT, Inouye SK and Oh ES. Delirium in the elderly. *Clin Geriatr Med* 2020; 36: 183–199.

7. Chen H, Mo L, Hu H, et al. Risk factors of postoperative delirium after cardiac surgery: a meta-analysis. *J Cardiothorac Surg* 2021; 16: 13.

8. Greaves D, Psaltis PJ, Ross TJ, et al. Cognitive outcomes following coronary artery bypass grafting: a systematic review and meta-analysis of 91,829 patients. *Int J Cardiol* 2019; 289: 43–49.

9. Kirfel A, Menzenbach J, Guttenthaler V, et al. Postoperative delirium after cardiac surgery of elderly patients as an independent risk factor for prolonged length of stay in intensive care unit and in hospital. *Aging Clin Exp Res* 2021; 33: 3047–3056.

10. de la Varga-Martínez O, Gutiérrez-Bustillo R, Muñoz-Moreno MF, et al. Postoperative delirium: an independent risk factor for poorer quality of life with long-term cognitive and functional decline after cardiac surgery. *J Clin Anesth* 2023; 85: 111030.

11. Devlin JW, Skrobik Y, Gélinas C, et al. Clinical practice guidelines for the prevention and management of pain, agitation/sedation, delirium, immobility, and sleep disruption in adult patients in the ICU. *Crit Care Med* 2018; 46: e825–e873.

12. Kotfis K, van Diem-Zaal I, Williams Roberson S, et al. The future of intensive care: delirium should no longer be an issue. *Crit Care* 2022; 26: 00.

13. Wilson JE, Mart MF, Cunningham C, et al. Delirium. *Nat Rev Dis Primers* 2020; 6: 90. Published 2020 Nov 12.

14. Bramley P, McArthur K, Blayney A, et al. Risk factors for postoperative delirium: an umbrella review of systematic reviews. *Int J Surg* 2021; 93: 106063.

15. Siew ED, Fissell WH, Tripp CM, et al. Acute kidney injury as a risk factor for delirium and coma during critical illness. *Am J Respir Crit Care Med* 2017; 195: 1597–1607.

16. Tonna JE, Dalton A, Presson AP, et al. The effect of a quality improvement intervention on sleep and delirium in critically ill patients in a surgical ICU. *Chest* 2021; 160: 899–908.

17. Gimpel D, Shanbhag S, Srivastava T, et al. Early discharge from intensive care after cardiac surgery is feasible with an adequate fast track, stepdown unit: Waikato experience. *Heart Lung Circ* 2019; 28: 1888–1895.

18. Gaudreau JD, Gagnon P, Harel F, et al. Fast, systematic, and continuous delirium assessment in hospitalized patients: the Nursing Delirium Screening Scale. *J Pain Symptom Manage* 2005; 29: 368–375.

19. Kim KN, Kim CH, Kim KI, et al. Development and validation of the Korean nursing delirium scale. *J Korean Acad Nurs* 2012; 42: 414–423.

20. Wong DT and Knaus WA. Predicting outcome in critical care: the current status of the APACHE prognostic scoring system. *Can J Anaesth* 1991; 38: 374–383.

21. Yoo CS, Sim MY and Choi EH. Development of Korean Patient Classification System for critical care nurses. *J Korean Clin Nurs Res* 2015; 21: 401–411.

22. Bowdish ME, D'Agostino RS, Thourani VH, et al. The society of thoracic surgeons adult cardiac surgery database: 2020 update on outcomes and research. *Ann Thorac Surg* 2020; 109: 1646–1655.

23. Noh EY and Park YH. Prevalence of delirium and risk factors in heart surgery patients in intensive care unit: a retrospective study. *Korean J Adult Nurs* 2019; 31: 146–155.
24. Wang Y and Bellomo R. Cardiac surgery-associated acute kidney injury: risk factors, pathophysiology and treatment. *Nat Rev Nephrol* 2017; 13: 697–711.
25. Mart MF, Williams Roberson S, Salas B, et al. Prevention and management of delirium in the intensive care unit. *Semin Respir Crit Care Med* 2021; 42: 112–126.
26. Habeeb-Allah A and Alshraideh JA. Delirium post-cardiac surgery: incidence and associated factors. *Nurs Crit Care* 2021; 26: 150–155.
27. Gilbey T, Milne B, de Somer F, et al. Neurologic complications after cardiopulmonary bypass - a narrative review. *Perfusion* 2023; 38: 1545–1559.
28. Şaşkin H, Özcan KS and Yildirim S. The role of inflammatory parameters in the prediction of postoperative delirium in patients undergoing coronary artery bypass grafting. *Cardiovasc J Afr* 2022; 33: 296–303.
29. Saxena S and Maze M. Impact on the brain of the inflammatory response to surgery. *Presse Med* 2018; 47: e73–e81.
30. Peng C, Wang M, Geng Y, et al. Risk factors for postoperative delirium in ICU patients with severe illness based on systematic review and meta-analysis. *Ann Palliat Med* 2022; 11: 309–320.
31. He E, Dong Y, Jia H, et al. Relationship of sleep disturbance and postoperative delirium: a systematic review and meta-analysis. *Gland Surg* 2022; 11: 1192–1203.