Delirium is associated with failure to rescue after cardiac surgery

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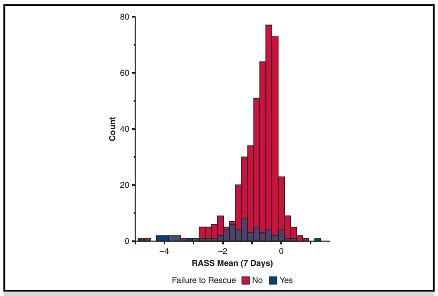
ABSTRACT

Objective: Postoperative delirium after cardiac surgery is associated with long-term cognitive decline and mortality. We investigated whether increased ICU Confusion Assessment Method scores were associated with greater 30-day mortality and failure to rescue after cardiac surgery.

Methods: We studied 4030 patients who underwent a Society of Thoracic Surgeons index operation at the University of Virginia Health System from 2011 to 2021. We obtained all ICU Confusion Assessment Method scores recorded during patients' admission and summarized scores for the first 7 postoperative days. Univariate and multivariable logistic regression analyzed the association between ICU Confusion Assessment Method score/delirium presence and postoperative complications, operative mortality, and failure to rescue.

Results: Any episode of ICU Confusion Assessment Method screen-positive delirium and nearly all components of the score were associated with increased 30-day mortality on univariate analysis. We found that a single episode of delirium was associated with increased mortality. Feature 2 (inattention) had the strongest association with poorer outcomes, including failure to rescue in our analysis, as were patients with higher peak Richmond Agitation Sedation Scale scores. Patients with higher mean Richmond Agitation Sedation Scale scores had an association with decreased failure to rescue.

Conclusions: A single episode of delirium, as measured using ICU Confusion Assessment Method scores, is associated with increased mortality. Inattention and higher peak Richmond Agitation Sedation Scale scores were associated with failure to rescue. Screening may clarify diagnosing delirium and assessing its implications on mortality and failure to rescue. Our findings suggest the importance of identifying and managing risk factors for delirium to improve patient outcomes and reduce mortality and failure to rescue rates. (JTCVS Open 2023;16:464-76)



RASS mean (7 days) histogram with FTR differentiated by color.

CENTRAL MESSAGE

We found that delirium and episodes of agitation or combativeness in the ICU are associated with greater mortality and FTR after cardiac surgery.

PERSPECTIVE

Delirium can be a subtle and challenging clinical condition to diagnosis and manage. Subtle changes in mental status may be associated with increased mortality and FTR in patients after cardiac surgery.

See Discussion on page 477.

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Delirium is a common complication after cardiac surgery that affects up to 50% of patients.[1,2] It is characterized by acute changes in attention, cognition, and consciousness.[3,4] Delirium is associated with increased morbidity and mortality, especially in younger individuals and in those without prior stroke.[1,2] However, delirium is often underdiagnosed and undertreated in the intensive care unit (ICU), where most cardiac surgery patients are admitted postoperatively.[4,5]

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Abbreviations and Acronyms

CAM-ICU	= ICU Confusion Assessment Method
FTR	= failure to rescue
ICU	= intensive care unit
OR	= odds ratio
RASS	= Richmond Agitation Sedation Scale
STS	= Society of Thoracic Surgeons

One of the tools that can be used to screen for delirium in the ICU is the ICU Confusion Assessment Method (CAM-ICU), which is an adaptation of the CAM that was originally developed to allow nonpsychiatrists to assess delirium at the bedside.[3,4] The method is simple to perform at the bedside and can be implemented into an electronic health record as part of standard charting. The CAM-ICU consists of 4 features: acute onset or fluctuation (Feature 1), inattention (Feature 2), altered level of consciousness (Feature 3), and disorganized thinking (Feature 4). A patient is diagnosed with delirium if he or she has Features 1 and 2 plus either Feature 3 or 4.[4,5] The components of the score are shown in Table E1.

The Society of Thoracic Surgeons (STS) defines failure to rescue (FTR) as mortality after complications such as permanent stroke, renal failure, reoperation, or prolonged ventilation after cardiac surgery and uses this metric to evaluate the quality of care in cardiac surgery centers. A high FTR rate suggests lower-quality care, and a low rate indicates higher-quality care.[6] The phenomenon is generally thought to be influenced by hospital factors as much as or more than individual patient factors.[7-12] Factors that improve hospital efficiency and capability or that provide a greater safety net for patients, such as rapid response teams or higher case volume, appear to reduce FTR incidence or have an association with lower incidence.[9,13-16]

The nature of delirium is that it can reduce the ability of patients to communicate problems and cloud their clinical picture. The reaction of the team to the development of delirium can be the difference between resolution of the condition and further iatrogenesis. The condition is associated with increased ICU mortality, and we hypothesized that FTR will be increased in a population with delirium.[17] The association between delirium and FTR is poorly documented in the current medical literature. The aim of this article is to review the literature on delirium after cardiac surgery and its impact on mortality and FTR, and to determine how individual features of the score and the overall score are associated with these outcomes.

MATERIALS AND METHODS

Patient Data

The study was approved by the University of Virginia Institutional Review Board with waiver of consent (Protocol #23305 on February 14, 2021). We obtained patient demographic and outcomes data from the STS database for adult patients undergoing cardiac surgery at the University of Virginia Health System from 2011 to 2021. We collected CAM-ICU scores through a data request from our electronic medical record and matched them to their respective STS patient records. Patients were included if they underwent an STS index case and had more than 2 recorded CAM-ICU scores. Figure 1 shows the details.

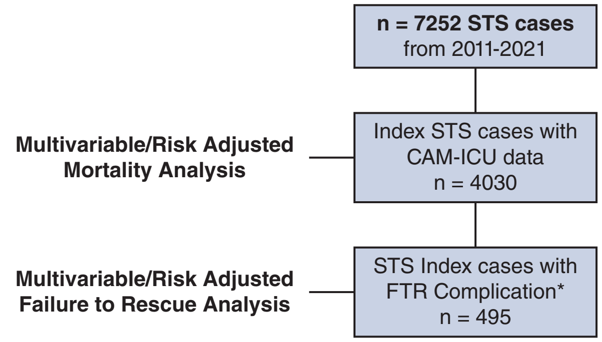

FIGURE 1. CONSORT diagram. *A patient with an FTR complication is defined as experiencing prolonged postoperative ventilation, renal failure, reoperation for any reason, or permanent stroke. A mortality in this subgroup is considered to be FTR. *STS*, Society of Thoracic Surgeons; *CAM-ICU*, ICU Confusion Assessment Method; *FTR*, failure to rescue.

Reporting of Statistical Results

We adhered to the guidelines provided in the Strengthening the Reporting of Observational Studies in Epidemiology and Transparent Reporting of a Multivariable Prediction Model for Individual Prognosis or Diagnosis statements. Continuous variables were reported as median (Q1, Q3) or mean (standard deviation), and categorical variables as n (%), following standard STS variable definitions.

How Can We Make Sense of ICU Confusion Assessment Method Scores Over Time?

CAM-ICU scores were collected on every shift and patient in our postoperative cardiac surgery ICU by nursing staff. There is a protocol for the nurse to notify the Nurse Practitioner/Physician Assistant/Physician directly caring for the patient with a positive screen or any change in mental status. We included all records in the first 7 days after surgery. Given the challenge of multiple recordings per patient, we sought to summarize the scores in a few ways. Several fields were created. "Percentage of recordings of delirium" shows what percentage of a patients' recorded scores were CAM-ICU positive. If a single patient had 1 positive recording of 5, then his/her percentage would be 0.2. Our reasoning was that a higher percentage would indicate a greater amount of delirium. This also could be a proxy for delirium severity. To increase the granularity of our analysis, we examined the individual features and if they had a positive record over the 7-day period. Our goal was to create a more global picture of each patient's mental status in their early postoperative period.

Individual Components of the ICU Confusion Assessment Method Score and Richmond Agitation Sedation Scale

Although it is customary to use the CAM-ICU as a composite tool, we chose to analyze the impact of each feature on patient outcomes separately. This unconventional approach was driven by our a priori hypothesis that different features of delirium may differentially impact patient outcomes, with potential synergistic effects when present together.

We considered that clinical consensus often accentuates the importance of inattention in delirium diagnosis, suggesting a possible unequal weighting of CAM-ICU elements.[5,18] By individually assessing each delirium feature while controlling for other factors, we aimed to maintain statistical independence of each feature. For each patient, we recorded the maximum or highest single occurrence of each delirium feature over a 7-day period. Regardless of the number of times a particular feature was observed, its score was recorded as "1," signifying the presence of the feature. Additionally, we opted to use the mean Richmond Agitation Sedation Scale (RASS) score as an overall indicator of sedation or agitation levels over the 7-day period. We did this because we aimed to provide a continuous measure that reflects the overall trend of the patient's agitation or sedation level during this time frame.

This unique methodological approach, although necessitating further validation, is intended to contribute additional perspectives to the ongoing discussion on effective delirium screening and management.

Outcomes and Delirium

We used the STS major morbidities as the basis for identifying patients who experienced an FTR complication. A patient was identified as having an FTR complication if he or she had postoperative renal failure or stroke, had to be reoperated for any reason, or required prolonged postoperative ventilation for more than 24 hours. FTR, in this context, was specifically defined as the occurrence of death in a patient who had experienced 1 of these FTR complications. In other words, a patient's death was only classified as FTR if he/she had a recorded instance of 1 of these specified FTR complications. The remainder of patients in the FTR complications subgroup could be considered to be rescued if they did not die. Postoperative renal failure was defined as Kidney Disease Improving Global Outcomes stage 2 acute kidney injury or greater, or new requirement for dialysis after surgery. STS outcomes are not reported with timing information on postoperative events. For that reason, we found whether a patient was positive for the composite score or any feature of the score over a 1-week period after admission. The RASS scores were collected and reported similarly. RASS score mean was reported as a proxy for the level of sedation or agitation over the 7-day period.

Selection

We divided the study into 2 major subgroups: (1) all patients with CAM-ICU scores who underwent an STS index operation over the study period and (2) all patients within that group that experienced an STS FTR complication. This allows us to examine differences in FTR with varying CAM-ICU scoring and RASS scores.

Statistical Analysis

Differences between baseline covariates were compared using chi-square or Fisher tests for categorical measures, and Student *t* test or Mann–Whitney *U* tests for continuous measures based on normality. Univariate analyses compared the association between increasing CAM-ICU score and CAM-ICU score feature and mortality. A risk-adjusted analysis was performed using the predicted risk of FTR, including both intraoperative factors and the STS predicted risk of mortality.[6] Rstudio and the R programming language were used for statistical analysis.[19] The specific packages used and a sample of the code used to perform the analysis are shown in the Appendix E1.

RESULTS

Study Population

There were 4030 patients who underwent STS index operations and had appropriate CAM-ICU score data from 2011 to 2021. There were 495 patients who experienced complications in that group (Figure 1).

PREOPERATIVE CHARACTERISTICS

Patient characteristics were compared between those who experienced delirium and those who did not in a cohort of 4030 patients (no delirium n = 3640; delirium n = 390) who underwent an STS index operation. The delirium group had a higher proportion of female patients and higher rates of comorbidities, including diabetes, cerebrovascular disease, hypertension, prior myocardial, peripheral arterial disease, chronic lung disease, preoperative dialysis, bilateral and unilateral carotid stenosis, carotid surgery, prior cerebrovascular accident, prior cardiac intervention, heart failure, aortic stenosis, and aortic valve regurgitation. The delirium group also had lower hematocrit, higher creatinine, and higher international normalized ratio, all with statistically significant differences. The predicted risk of mortality was more than double in the delirium group compared with the nondelirium group. Patients who experienced delirium had longer cardiopulmonary bypass times and received more intraoperative blood products than those who did not experience delirium. They also had a higher proportion of aortic valve replacement + coronary artery bypass and mitral valve replacement only procedures and were more likely to undergo urgent surgery. Full details are shown in Table 1.

THE COHORT

There were 8.85 CAM-ICU recordings per patient. Patients with delirium experienced a significantly higher incidence of postoperative complications, including permanent stroke, prolonged ventilation, cardiac arrest, reintubation, renal failure, and operative mortality. However, reoperation for bleeding, reoperation for nonbleeding, postoperative myocardial reintervention, postoperative sepsis, and postoperative ejection fraction were not significantly different between the 2 groups. One exception to this difference in complication rates between the groups is that the rate of atrial fibrillation was lower in the delirium group. These findings are shown in Table 2, and the mean RASS scores for each cohort are shown in Table E2.

A multivariable analysis of the STS index operation cohort (n = 4030) was performed using Predicted Risk of Mortality. In this model, the mean total CAM-ICU score and all features except for the mean of feature 1 were associated with increased mortality. RASS score was still associated with decreased mortality. The percentage of positive delirium records was not associated with increased mortality in this model as described in Table E3. This relationship is graphically represented in Figure 2.

COMPLICATIONS SUBGROUP

There were 495 patients who developed an STS FTR–qualifying complication (no delirium n = 364; delirium n = 131). There were no significant differences

TABLE 1. Baseline demographics and intraoperative characteristics in overall cohort

Variable	No delirium, N = 3640*	Any delirium, N = 390*	*P* value†
Age, y	67 (59-74)	71 (64-78)	<.001
Gender			.027
Female	1126 (31%)	142 (36%)	
Male	2514 (69%)	248 (64%)	
Primary payor			
Charitable care/foundation funding	1 (<0.1%)	0 (0%)	
Commercial health insurance	371 (10%)	17 (4.4%)	
Correctional facility	1 (<0.1%)	0 (0%)	
Medicaid	53 (1.5%)	9 (2.3%)	
Medicaid (includes commercially managed options)	13 (0.4%)	2 (0.5%)	
Medicare	729 (20%)	79 (20%)	
Medicare (includes commercially managed options)	134 (3.7%)	29 (7.4%)	
Military	5 (0.1%)	2 (0.5%)	
Military health	10 (0.3%)	1 (0.3%)	
None/self	62 (1.7%)	3 (0.8%)	
Other government insurance	2 (<0.1%)	0 (0%)	
State-specific plan	2 (<0.1%)	0 (0%)	
Unknown	2257 (62%)	248 (64%)	
History of diabetes	1456 (40%)	201 (52%)	<.001
History of cerebrovascular disease			<.001
No	2878 (79%)	250 (64%)	
Unknown	2 (<0.1%)	0 (0%)	
Yes	760 (21%)	140 (36%)	
History of immunocompromise	171 (4.7%)	19 (4.9%)	.9
Tobacco use			.5
Current every-day smoker	496 (14%)	54 (14%)	
Current some-day smoker	47 (1.3%)	1 (0.3%)	
Former smoker	1116 (31%)	123 (32%)	
Never smoker	1979 (54%)	212 (54%)	
Smoking status unknown	2 (<0.1%)	0 (0%)	
History of hypertension	2950 (81%)	337 (86%)	.009
Prior MI			.03
No	2102 (58%)	199 (51%)	
Unknown	5 (0.1%)	0 (0%)	
Yes	1533 (42%)	191 (49%)	
Prior PCI	833 (23%)	102 (26%)	.14
Time since last PCI (where known)			.3
≤6 h	5 (0.1%)	0 (0%)	
>6 h	828 (23%)	102 (26%)	
No PCI	2807 (77%)	287 (74%)	
BSA	2.88 (2.75-3.00)	2.84 (2.71-2.96)	.009
History of peripheral arterial disease	516 (14%)	109 (28%)	<.001
History of chronic lung disease			<.001
Lung disease documented, severity unknown	28 (0.8%)	5 (1.3%)	
Mild	611 (17%)	84 (22%)	
Moderate	204 (5.6%)	29 (7.4%)	
No	2646 (73%)	240 (62%)	
Severe	151 (4.1%)	32 (8.2%)	
Last WBC count	7.50 (6.10-9.06)	7.54 (6.36-9.00)	.3
Last platelet count	211,000 (173,000-255,000)	201,000 (164,250-253,750)	.03

(Continued)

TABLE 1. Continued

Variable	No delirium, N = 3640*	Any delirium, N = 390*	*P* value†
Preoperative renal failure or dialysis			.016
No	3551 (98%)	371 (95%)	
Unknown	1 (<0.1%)	0 (0%)	
Yes	88 (2.4%)	19 (4.9%)	
Preoperative INR	1.00 (1.00-1.10)	1.10 (1.00-1.20)	<.001
History of endocarditis	131 (3.6%)	27 (6.9%)	.001
History of TIA			.4
No	3494 (96%)	373 (96%)	
Unknown	3 (<0.1%)	1 (0.3%)	
Yes	141 (3.9%)	16 (4.1%)	
History of carotid stenosis			.009
Both	102 (2.8%)	22 (5.6%)	
Left	145 (4.0%)	17 (4.4%)	
None	3249 (89%)	328 (84%)	
Not documented	5 (0.1%)	0 (0%)	
Right	137 (3.8%)	23 (5.9%)	
Degree of left carotid stenosis			.083
<50% or not known	3393 (93%)	351 (90%)	
100%	11 (0.3%)	1 (0.3%)	
50% to 79%	217 (6.0%)	36 (9.2%)	
80% to 99%	19 (0.5%)	2 (0.5%)	
Degree of right stenosis			.006
<50% or not known	3401 (93%)	345 (88%)	
100%	9 (0.2%)	1 (0.3%)	
100%	1 (<0.1%)	0 (0%)	
50% to 79%	214 (5.9%)	41 (11%)	
80% to 99%	15 (0.4%)	3 (0.8%)	
Prior CVA			<.001
No	451 (12%)	73 (19%)	
None	2878 (79%)	250 (64%)	
Unknown	2 (<0.1%)	0 (0%)	
Yes	307 (8.4%)	67 (17%)	
Prior carotid surgery	94 (2.6%)	19 (4.9%)	.009
History of home oxygen			.4
No	3539 (97%)	379 (97%)	
Unknown	3 (<0.1%)	0 (0%)	
Yes	25 (0.7%)	3 (0.8%)	
Yes, oxygen dependent	43 (1.2%)	2 (0.5%)	
Yes, PRN	30 (0.8%)	6 (1.5%)	
Preoperative MELD score	7.5 (6.4-9.6)	8.9 (7.5-11.5)	<.001
History of liver disease			.3
No	3486 (96%)	368 (94%)	
Unknown	1 (<0.1%)	0 (0%)	
Yes	153 (4.2%)	22 (5.6%)	
Preoperative albumin	4.00 (3.70-4.25)	3.80 (3.50-4.10)	<.001
History of mediastinal radiation	68 (1.9%)	3 (0.8%)	.12
History of illicit drug use in the last year			.2
No	3430 (94%)	368 (94%)	
Recent	56 (1.5%)	6 (1.5%)	
Remote	118 (3.2%)	11 (2.8%)	
Unknown	19 (0.5%)	0 (0%)	
Yes	17 (0.5%)	5 (1.3%)	

(Continued)

TABLE 1. Continued

Variable	No delirium, N = 3640*	Any delirium, N = 390*	*P* value†
Previous cardiac intervention			.007
No	2344 (64%)	230 (59%)	
Unknown	0 (0%)	1 (0.3%)	
Yes	1296 (36%)	159 (41%)	
Prior valve surgery	114 (3.1%)	14 (3.6%)	.6
Prior CAB	123 (3.4%)	16 (4.1%)	.5
MI timing			.068
≤6 h	6 (0.2%)	0 (0%)	
>21 d	660 (18%)	80 (21%)	
>6 h but <24 h	27 (0.7%)	5 (1.3%)	
1-7 d	723 (20%)	96 (25%)	
8-21 d	117 (3.2%)	10 (2.6%)	
Unknown	2107 (58%)	199 (51%)	
Heart failure			.006
No	3141 (86%)	313 (80%)	
Unknown	2 (<0.1%)	0 (0%)	
Yes	497 (14%)	77 (20%)	
Heart failure timing			.014
Acute	95 (2.6%)	15 (3.8%)	
Both	75 (2.1%)	12 (3.1%)	
Chronic	327 (9.0%)	50 (13%)	
No HF	3141 (86%)	313 (80%)	
NYHA classification			.006
Class I	58 (1.6%)	8 (2.1%)	
Class II	220 (6.0%)	26 (6.7%)	
Class III	165 (4.5%)	32 (8.2%)	
Class IV	51 (1.4%)	10 (2.6%)	
No HF	3141 (86%)	313 (80%)	
Not documented	3 (<0.1%)	1 (0.3%)	
Resuscitation required			.073
No	3617 (99%)	384 (98%)	
Yes, >1 h but <24 h of the start of the procedure	21 (0.6%)	6 (1.5%)	
Yes, within 1 h of the start of the procedure	2 (<0.1%)	0 (0%)	
No. of diseased vessels (CAB)			
None	957 (26%)	67 (17%)	
Not documented	34 (0.9%)	5 (1.3%)	
1	310 (8.5%)	38 (9.7%)	
3	1703 (47%)	198 (51%)	
2	636 (17%)	82 (21%)	
Aortic stenosis	1423 (39%)	176 (45%)	.021
Mitral stenosis	139 (3.8%)	22 (5.6%)	.081
Mitral regurgitation			.3
Mild	896 (25%)	112 (29%)	
Moderate	350 (9.6%)	42 (11%)	
None	877 (24%)	79 (20%)	
Not documented	123 (3.4%)	9 (2.3%)	
Severe	505 (14%)	54 (14%)	
Trivial/trace	889 (24%)	94 (24%)	

(Continued)

TABLE 1. Continued

Variable	No delirium, N = 3640*	Any delirium, N = 390*	*P* value†
Tricuspid regurgitation			
Mild	926 (25%)	97 (25%)	
Moderate	234 (6.4%)	42 (11%)	
None	771 (21%)	89 (23%)	
Not documented	153 (4.2%)	15 (3.8%)	
Severe	42 (1.2%)	8 (2.1%)	
Trivial/trace	1514 (42%)	139 (36%)	
Aortic valve regurgitation	86 (2.4%)	18 (4.6%)	.008
Last creatinine level	1.00 (0.80-1.20)	1.10 (0.90-1.40)	<.001
Last hematocrit	40.3 (36.4-43.5)	38.0 (33.5-41.3)	<.001
Ejection fraction	57 (47-63)	57 (43-63)	.045
Intraoperative factors			
Procedure type			
AV replacement	684 (19%)	55 (14%)	
AV replacement + CAB	321 (8.8%)	68 (17%)	
CAB only	1975 (54%)	195 (50%)	
MV repair	335 (9.2%)	21 (5.4%)	
MV repair + CAB	68 (1.9%)	10 (2.6%)	
MV replacement + CAB	29 (0.8%)	4 (1.0%)	
MV replacement only	228 (6.3%)	37 (9.5%)	
Crossclamp time (min)	78 (62-98)	83 (62-108)	.003
Cardiopulmonary bypass time (min)	103 (83-131)	112 (86-144)	<.001
Intra-aortic balloon pump	189 (5.5%)	27 (7.6%)	.11
Surgery status			.001
Elective	2162 (59%)	194 (50%)	
Emergency	42 (1.2%)	8 (2.1%)	
Emergency salvage	2 (<0.1%)	0 (0%)	
Urgent	1434 (39%)	188 (48%)	
Predicted risk of mortality	0.015 (0.008-0.031)	0.032 (0.016-0.060)	<.001
Intraoperative blood products			<.001
No	2264 (62%)	183 (47%)	
No, not given	193 (5.3%)	22 (5.7%)	
Yes	1177 (32%)	184 (47%)	
Intraoperative blood products (packed red blood cells)	0.00 (0.00-1.00)	1.00 (0.00-2.00)	<.001

MI, Myocardial infarction; *PCI*, percutaneous coronary intervention; *BSA*, body surface area; *WBC*, white blood cell; *AV*, aortic valve; *INR*, international normalized ratio; *TIA*, transient ischemic attack; *CVA*, cardiovascular accident; *PRN*, pro re nata; *MELD*, Model for End-stage Liver Disease; *CAB*, coronary artery bypass; *HF*, heart failure; *NYHA*, New York Heart Association; *MV*, mitral valve. *Median (interquartile range); n (%); range. †Wilcoxon rank-sum test; Pearson's chi-square test; Fisher exact test; Wilcoxon rank-sum exact test.

between the 2 groups in terms of age, gender, or ejection fraction. The most common procedures performed were coronary artery bypass only (52% in the no delirium group vs 45% in the delirium group), aortic valve replacement (13% vs 14%), and mitral valve repair (6.6% vs 3.1%). There were no significant differences in crossclamp time or cardiopulmonary bypass time between the 2 groups.

Reoperation for bleeding was more common in the no delirium group than in the delirium group (26% vs 17%, $P = .032$), as was stroke (10% vs 21%, $P = .001$). Reintubation was also more common in the delirium group (53% vs 38%, $P = .056$). Postoperative ejection fraction was significantly higher in the delirium group (median 57 vs 53, $P = .021$). The Predicted Risk of Mortality was higher in the delirium group (4% vs 3%, $P = .01$). Other complications were similar between groups (Table 2).

FAILURE TO RESCUE

Eight models were created that incorporated predicted risk of FTR and the percentage of positive CAM-ICU scores, RASS, and each feature of the CAM-ICU score. The features were examined independently with each being incorporated into a separate model. There were 495 patients who underwent STS index operations and experienced an FTR complication. The results indicate that mean RASS had the strongest association with decreased odds of FTR, with an odds ratio (OR) of 0.49. A positive record of Feature 2 (inattention) showed a significant association with increased odds of FTR, with an OR of 2.01 and a *P* value

TABLE 2. Postoperative outcomes in the group who experienced delirium compared with those who did not

Variable	No delirium, N = 3640*	Any delirium, N = 390*	*P* value†
Reoperation for bleeding	95 (7.2%)	22 (9.1%)	.3
Permanent stroke			<.001
No	1285 (97%)	213 (88%)	
Yes	7 (0.5%)	9 (3.7%)	
Yes, embolic	8 (0.6%)	9 (3.7%)	
Yes, hemorrhagic	2 (0.2%)	2 (0.8%)	
Yes, ischemic	16 (1.2%)	7 (2.9%)	
Yes, undetermined type	4 (0.3%)	1 (0.4%)	
Prolonged postoperative ventilation >24 h	259 (20%)	91 (38%)	<.001
Postoperative cardiac arrest	52 (1.4%)	11 (2.8%)	.035
Postoperative reintubation	62 (4.5%)	28 (20%)	<.001
Total postoperative hours on ventilator	53 (24-214)	45 (25-308)	>.9
Postoperative atrial fibrillation	939 (71%)	132 (55%)	<.001
Reoperation for nonbleeding	10 (0.8%)	5 (2.1%)	.067
Postoperative myocardial reintervention	3 (0.5%)	2 (2.2%)	.15
Postoperative renal failure	92 (7.0%)	34 (14%)	<.001
Postoperative sepsis	29 (2.2%)	7 (2.9%)	.5
Postoperative ejection fraction	53 (43-63)	53 (43-63)	.6
Operative mortality	60 (1.6%)	18 (4.6%)	<.001
Percent of delirium per CAM-ICU	0.00 (0.00-0.00)	0.13 (0.06-0.25)	<.001

CAM-ICU, ICU Confusion Assessment Method. *Median (interquartile range); n (%); range. †Wilcoxon rank-sum test; Pearson's chi-square test; Fisher exact test; Wilcoxon rank-sum exact test.

of .047. The highest 7-day mean RASS was 1.75. In contrast, the higher the 7-day maximum RASS, the greater the OR of FTR (OR, 1.20, CI, 1.00-1.43, $P = .047$). The remaining variables did not show a significant association with FTR. Table 3 shows the composite of the 8 individual risk-adjusted models, with each row representing a different model. The complete results of the risk-adjusted model for the maximum inattention score are shown in Table 4 and serve as an example of how the other models were structured. The visual relationship between RASS scores and FTR is shown in the Figure 3.

DISCUSSION

Our study analyzed 4030 patients who underwent STS operations from 2011 to 2021, 495 of whom experienced complications. Patients who experienced delirium had higher prevalence of comorbidities and were more likely to undergo urgent surgery. They also had a significantly higher incidence of permanent stroke, prolonged postoperative ventilation, postoperative cardiac arrest, postoperative reintubation, postoperative renal failure, and operative mortality. The mortality rate was twice as high in the delirium group. Our initial analysis found that an increase in the number of positive CAM-ICU scores or any feature of the score was associated with greater mortality, whereas a higher mean RASS score was associated with lower mortality. In the subgroup of 495 patients who experienced an STS FTR complication, our multivariable, risk-adjusted analyses identified that increasing 7-day mean RASS score had the strongest association with decreased odds of FTR, whereas a higher peak inattention score (Feature 2) and higher maximum RASS showed a significant association with increased odds of FTR. These findings suggest that more awake patients are less likely to experience FTR, but that even transient agitation or combativeness is associated with FTR. These findings highlight the mental status balancing act familiar to ICU physicians and cardiac surgeons.

INCIDENCE OF DELIRIUM

The rates of delirium after cardiac surgery vary depending on the study and the method of assessment, but they are generally high. According to a meta-analysis by Chen and colleagues[20] and Brown,[21] the incidence of delirium after cardiac surgery ranges from 26% to 52% when estimated with rigorous methodology. Other studies have reported similar or lower rates, such as 11.3% to 51.6% by Cai and colleagues[22] and 20% by Ibrahim and colleagues.[23] The rate of delirium we report is 9.5%, which is lower than these reported rates. Delirium after cardiac surgery is

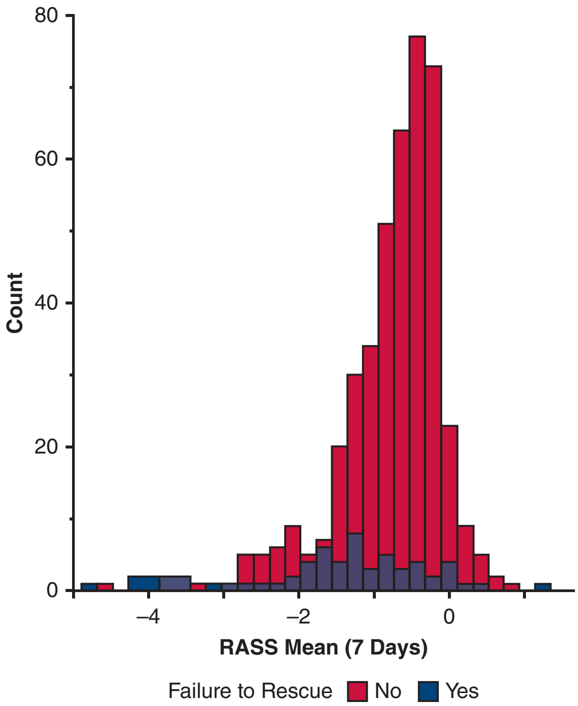

FIGURE 2. RASS mean (7 days) versus RASS max, colored and shaped by mortality, locally estimated scatterplot smoothing lines show trends. Low mean RASS and high max RASS scores are associated with increased clustering of FTR. *RASS*, Richmond Agitation Sedation Scale.

associated with increased mortality, morbidity, and long-term cognitive dysfunction.[24,25] After 3 and 6 months, patients were found to have a lower quality of life and greater mortality.[25]

A cross-sectional study of 590 contemporary cardiac ICU patients reported the rate of delirium at 20% and that those with delirium had higher ICU mortality (27% vs 3%; $P < .001$).[24] The association with increased mortality held true even 10 years after surgery in one retrospective study.[25] They reported an increased mortality rate of 16.0 per 100 person-years in those with delirium compared with 7.4 per

TABLE 3. Summary of 7 different multivariable models incorporating predicted risk of failure to rescue into the model

Characteristic	OR	95% CI	*P* value
Percentage of recordings of delirium	0.29	0.01-3.87	.397
Mean RASS	0.49	0.37-0.64	<.001
Max RASS	1.20	1.00-1.43	.047
Feature 1: AMS/baseline change	1.59	0.93-2.69	.087
Feature 2: Inattention	2.01	1.01-4.07	.047
Feature 3: Altered mental status	1.5	0.76-3.00	.246
Feature 4: Disorganized thinking	1.52	0.75-3.04	.24

OR, odds ratio; *RASS*, Richmond Agitation Sedation Scale; *AMS*, altered mental status. Each row in the table represents a different model structured the same as the one described in Table 4.

TABLE 4. Full risk-adjusted model for patients who were positive for Feature 2 (inattention)

Characteristic	OR	95% CI	*P* value
Inattention	2.01	1.01-4.07	.047
Predicted risk of mortality	331	6.50-17,311	.004
Cardiopulmonary bypass time	1	0.99-1.01	.6
Crossclamp time	1	0.99-1.02	.6
Preoperative support	4.9	2.20-11.1	<.001
Massive transfusion	1.55	0.07-13.8	.7
Unplanned operation	0.4	0.17-0.90	.03

OR, Odds ratio.

100 person-years in those without. Their findings suggested that delirium was independently associated with this increase in long-term mortality.[26,27] Our rate of mortality was 4.6% in those who experienced delirium compared with 1.6% in those who did not. Although the rates differ, the drastic increase in mortality in those with delirium remains. A meta-analysis suggests that delirium may be an independent risk factor for long-term cognitive decline in both surgical and nonsurgical patients.[26] Some risk factors for developing delirium after cardiac surgery are age, cognitive impairment, perioperative use of opioids, intraoperative transfusion, postoperative infection, postoperative atrial fibrillation, and longer aortic crossclamp time.[27,28] We found that patients who experienced complications had higher

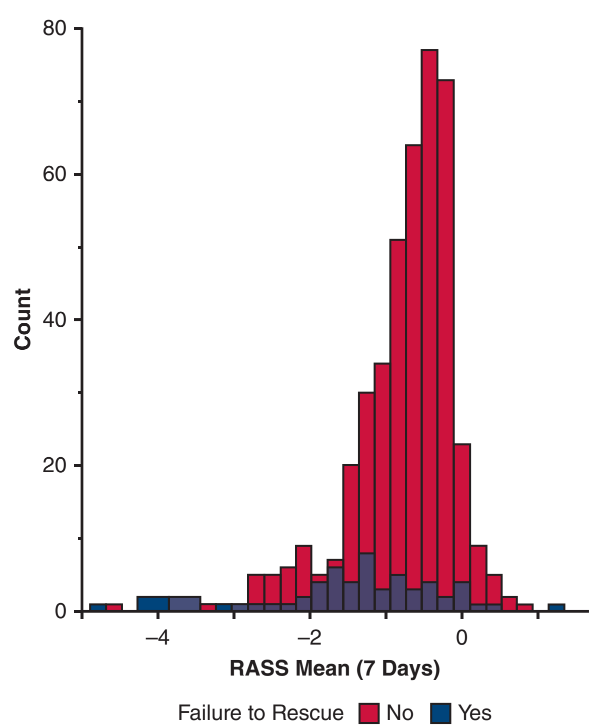

FIGURE 3. RASS mean (7 days) histogram with FTR differentiated by color. *RASS*, Richmond Agitation Sedation Scale.

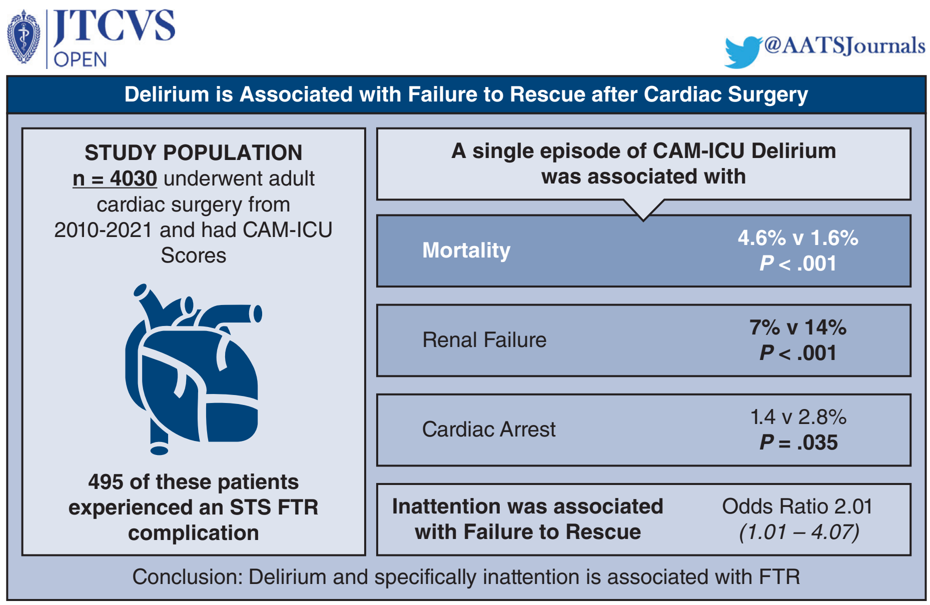

FIGURE 4. Graphical abstract describing the critical findings of the study. *CAM-ICU*, ICU Confusion Assessment Method; *STS*, Society of Thoracic Surgeons; *FTR*, failure to rescue.

rates of delirium with the exception that the development of atrial fibrillation was higher in the no-delirium group in our cohort. We lack clear data on preoperative cognitive impairment in our cohort, but delirium rates were higher in the cohort with a history of cerebrovascular disease.

DELIRIUM AND FAILURE TO RESCUE

Interpretation of the interplay between complications and delirium using STS data is challenging. We have information about the timing of delirium episodes, but we lack information on the timing of complications. As described previously, complications and intraoperative events are associated with the development of delirium, but there are also data to suggest that delirium leads to more complications, a longer length of stay, and higher costs.[1,29]

Data on the impact of ICU delirium on FTR are limited. We could not find any studies specifically describing the impact of ICU delirium on FTR, even in other populations. Our univariate analysis suggests that inattention, altered mental status, and disorganized thinking are all associated with increased FTR. The risk-adjusted analysis was less overt but suggests that if patients have an episode of inattention on their assessment, they have greater odds of developing FTR. Patients who are unable to communicate effectively are harder to assess for deterioration. The relationship between higher RASS scores and less FTR also supports this theory. Less sedation makes it easier to assess patients. Patients who develop delirium may have worse baseline cognition that is not captured with STS data. Even those with higher baseline cognitive function are in danger from delirium because they tend to lose more of their function than those with lower baseline function.[30] This may lead to issues adapting to life outside of the hospital and worse recognition of early problems.[31]

Use of sedative or analgesic medications in the perioperative period is unknown to us, but the finding that higher mean RASS scores were associated with less FTR suggests that minimizing the amount of time a patient is sedated may be important, with the context that the highest 7-day mean score was 1.75 in the complications cohort. This is reflected in guidelines for Enhanced Recovery after Cardiac Surgery that suggest minimizing delirium-precipitating medications and using analgesia that is less associated with delirium such as ketamine or dexmedetomidine.[32] The relationship between maximum 7-day RASS and increasing FTR suggests that even transient agitation or combativeness is harmful. This finding is aligned with prior research because a prospective study of ICU agitation found that it can be associated with unplanned extubation, central line removal, and prolonged ICU stay.[33]

STUDY LIMITATIONS

Retrospective cohort studies, although useful in exploring associations between risk factors and outcomes, have several limitations that researchers should consider. One such limitation is the limited control over data collection because we rely on good data quality from the STS database and in our health records. We also lack information on baseline cognitive status or on the presence of preoperative delirium, and there was no auditing process to confirm the accuracy of the bedside assessment. Additionally, retrospective cohort studies cannot establish causality, because there may be other factors that are not accounted for in the study that could be responsible for the observed associations. Confounding variables, selection bias, information bias, and confounding by indication are other potential limitations that researchers must consider when interpreting their results, even with our attempts to adjust for individual patient risk. Our study represents the outcomes at a single center and in a single ICU. This may limit the generalizability of our study to other institutions.

CONCLUSIONS

We found that patients who experienced delirium after cardiac surgery as defined by CAM-ICU scores had significantly higher rates of postoperative complications and a mortality rate that was more than double the rate of patients who did not experience delirium. Features of the CAM-ICU score independently contributed to FTR in univariate analyses. In our multivariable models, we found that inattention was independently associated with FTR, whereas other independent features and the composite score were not. More aware and attentive patients appeared to have better outcomes as reflected by higher mean RASS scores being associated with a lower OR of FTR, but this is balanced by the observation that higher 7-day maximum RASS scores are associated with increased FTR (Figure 4). Our findings support the importance of recognizing and managing delirium in patients after cardiac surgery. We aim to develop methods for determining complication timing in large patient cohorts via health record data. The timing of complications and ICU events is vital to understand the complex link between delirium and patient outcomes. With our current work as a foundation, we plan to further explore this relationship in future studies. With this better characterized, we can focus on early detection and prevention of delirium and associated complications.

Webcast

You can watch a Webcast of this AATS meeting presentation by going to: https://www.aats.org/resources/delirium-is-associated-with-failure-to-rescue-after-cardiac-surgery.

Conflict of Interest Statement

The authors reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling or reviewing manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

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Key Words: delirium, failure to rescue, perioperative care

TABLE E1. Summary of CAM-ICU scoring

Feature	Criteria
Level of consciousness	RASS score must be −3 or higher
1: Acute onset or fluctuation	Positive if there is evidence of acute change or fluctuation in mental status from baseline
2: Inattention	Positive if patient has difficulty focusing attention (eg, makes errors on letter cancellation test)
3: Altered level of consciousness	Positive if patient's level of consciousness is anything other than alert (eg, vigilant, lethargic, stupor)
4: Disorganized thinking	Positive if patient gives illogical answers to questions (eg, "Will a stone float on water?") or commands (eg, "Hold up 2 fingers")

Patients must not be sedated and be positive for components 1 and 2 to be assessed for components 3 and 4. If they are positive for 1 and 2 and either 3 or 4, they have delirium according to the tool. *CAM-ICU*, ICU Confusion Assessment Method; *RASS*, Richmond Agitation Sedation Scale.

TABLE E2. Univariate analysis of different components of CAM-ICU score on mortality in the first 7 days after surgery: This was performed on all patients and includes nonindex cases

Characteristic	N	Event N	OR	95% CI	*P* value	q-value*
Percentage of recordings of delirium	5861	184	7.94	2.18-24.0	.003	0.003
Mean RASS	7252	248	0.25	0.22-0.28	<.001	<0.001
1: AMS/Baseline change max	6585	144	1.71	1.39-2.09	<.001	<0.001
2: Inattention max	5577	120	4.51	3.13-6.50	<.001	<0.001
3: Altered mental status max	5538	127	4.48	3.13-6.50	<.001	<0.001
4: Disorganized thinking max	5455	112	4.05	2.77-5.91	<.001	<0.001

CAM-ICU, ICU Confusion Assessment Method; *OR*, odds ratio; *RASS*, Richmond Agitation Sedation Scale; *AMS*, altered mental status. *False discovery rate correction for multiple testing.

TABLE E3. Multivariable analysis of different components of CAM-ICU score on mortality in the first 7 days after surgery

Characteristic	OR	95% CI	*P* value
Percentage of recordings of delirium	4.84	0.47-28.37	.124
Mean RASS	0.29	0.23-0.36	<.001
1: AMS/baseline change max	1.55	1.13-2.10	.005
2: Inattention max	3.81	2.21-6.54	<.001
3: Altered mental status max	2.59	1.52-4.42	<.001
4: Disorganized thinking max	2.85	1.63-4.91	<.001

Patients who underwent index cases were included, and the model was risk adjusted with predicted risk of mortality. *CAM-ICU*, ICU Confusion Assessment Method; *OR*, odds ratio; *RASS*, Richmond Agitation Sedation Scale; *AMS*, altered mental status.