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# Delirium Following Cardiac Surgery: Incidence and Risk Factors

**Summary:** The purpose of this retrospective study was to determine the incidence of and risk factors for delirium in patients undergoing cardiac surgery. In addition, the influence of different post-surgical intensive care unit (ICU) environments on delirium incidence was also studied. A detailed clinical report form was created to collect pertinent data in order to determine the effect of pre-operative, intraoperative and postoperative variables on delirium. Our study identified several risk factors for an increased incidence of delirium: hypertension, preoperative statin use, coronary artery bypass graft (CABG) surgery, aortic valve surgery, advanced age, prolonged bypass time and lowest serum sodium value during surgery. Extubation in the OR was associated with a lower incidence of delirium. In our comparison of the different ICU environments, in the first cohort (environment #1), 19.2% of patients experienced at least one episode of delirium. In the second cohort (environment #2; enhanced by privacy, reduced noise, and natural light), the incidence was reduced to 11.1% ($p = 0.0582$). As the two cohorts had otherwise similar demographics and other perioperative characteristics, it is likely that the reduced incidence of delirium was attributable to the enhanced ICU environment.

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## Introduction

### *Background*

Delirium is an acute organic syndrome characterized by inattention, disorientation, along with global cognitive impairment and disturbances in consciousness.[1] Postoperative delirium is typically characterized by a fluctuating course and can be associated with either increased or decreased psychomotor activity.[2] Furthermore, patients affected by delirium often experience significant disturbances in their sleep-wake cycle.[3]

Delirium does not have a single cause, but is better described as having a multifactorial etiology. Several theories have been proposed regarding the development of delirium with various mechanisms including perioperative cerebral hypoperfusion (i.e. relative oxygen deprivation),[4] as well as a the result of overall physiologic stresses.[5] Altered neurotransmitter levels, neuronal aging,[6] inflammatory cytokine release,[7] and disturbances in intraneuronal signal transduction (i.e. disruption of second messenger systems) have also been described. It is likely that delirium results from the interaction of two or more of these potential mechanisms.[2] This pathophysiologic complexity of delirium contributes to its high prevalence in the setting of cardiac surgery. Delirium as a complication of cardiac surgery was first reported in the early years following the advent of modern-day cardiac surgery in 1953.[8] Despite advancements in cardiac surgery that have reduced the mortality and high morbidity previously experienced in the early decades of surgery, postoperative issues, notably delirium remains a significant concern and contributes to greater negative perioperative outcomes.[9,10] Delirium is considered an independent risk factor for prolonged length of hospital length of stay, as well as 6 month mortality.[11,12] Furthermore, postoperative delirium has significant financial implications, having been found to be associated with 39% higher intensive care unit (ICU) and 31% higher hospital costs.[10] For example, in the United States, the total additional healthcare costs attributed to delirium have been reported to be in excess of $4 billion in Medicare expenses.[11] Therefore, efforts towards delirium prevention could have a significant impact on the healthcare system and patient outcomes and are an area of intense interest.

### *Pathophysiology*

Delirium is thought to be the result of several interacting factors involving neurotransmitters, cytokines, other humoral factors as well as cerebral hypoperfusion. Cholinergic function is a key contributor to attention, memory, arousal and rapid-eye movement sleep. These cerebral physiologic functions can be altered if acetylcholine is deficient. For example, delirium has even hypothesized to be the result of disruption of fundamental cholinergic transmission with delirious patients having had low levels of acetylcholine (ACh) found in cerebrospinal fluid (CSF) and plasma.[13] During normal aging, there is a decline in the amount of acetylcholine-producing cells, and as a result, there is less ACh synthesized.[6] Delirium may also be related to increased levels of serum anticholinergic activity (SAA). It has even been suggested that there may be a dose-response relationship between delirium symptoms and SAA. Delirium may also be a result of an imbalance of several other neurotransmitters, which can be attributed to excess dopamine, norepinephrine and glutamate, as well as altered serotonergic and gamma-aminobutyric activity.[14]

Some medications have been found to be associated with delirium. In particular, those medications with psychoactive potential such as benzodiazepines, corticosteroids, nonsteroidal anti-inflammatory agents (NSAIDS), opiates and chemotherapeutic agents have been demonstrated to be a factor in delirium.[15] Drugs with anticholinergic potential may also lead to delirium. As previously mentioned, the relationship between SAA (indicative of a drug's anticholinergic potential)[16] and the development of delirium has been demonstrated in several studies.

Cardiac surgery patients recovering in the ICU are frequently affected by altered sleep-wake cycles that result in profound sleep deprivation. In the ICU, the average duration of sleep has been reported to be as low as 2 hours during any 24-hour time period.[17] It has been hypothesized that sleep deprivation in the critically ill may cause emotional distress, as well as contribute to neurocognitive dysfunction, decreased immune function, prolongation of mechanical ventilation and ICU delirium.[18] Thus, delirium in the post-cardiac surgery patient may occur partly as a result of altered sleep-wake cycles and its associated sleep deprivation.

During cardiac surgery, the patient undergoes trauma to which the body responds by activating a "systemic inflammatory response". This may also increase the risk of developing delirium. The inflammatory response is more pronounced with a greater primary insult.[19] Accordingly, cardiac surgery has a very pronounced inflammatory response as a response to excess blood loss and transfusions, extensive tissue trauma, ischemia and reperfusion of the myocardium, the use of CPB, and other causes.[20]

*Incidence*

The incidence of post-cardiac surgery delirium has been variably reported amongst different institutions. A review by Sockalingam et al reported the rates of postoperative delirium to range between 3 and 72%.[21] The variability may be due to lack of standardization of identification of postoperative delirium, changing patient demographics, but also to environmental differences in each center reporting results. Cardiac surgery patients are considered to have an increased risk of developing delirium compared to other surgery patients; it is one of the most distressing and common outcomes of such surgery. Even with such a high prevalence, delirium is often undiagnosed and thus, many patients are sent home without full resolution of symptoms.[22]

*Risk Factors*

There are many patient and operative risk factors that have been associated with delirium. Previous studies have found the following to be particularly important. Patient related demographic risk factors include advanced age, pre-existing dementia, hearing and visual impairment, alcohol abuse, smoking, decreased left ventricular ejection fraction, pre-existing pulmonary disease, hypertension, cerebrovascular disease are reported more frequently in those with delirium. [8,23,24,25] Procedural risk factors include prolonged surgery and cardiopulmonary bypass (CPB) times, anesthesia exposure, increased postoperative transfusion requirements, postoperative tachycardia or hypertension, atrial fibrillation, elevated blood urea level and pneumonia. [8,9,24,26] One objective of our study was to confirm if these risk factors and if other previously unidentified variables were relevant in our provincial cardiac surgical population.

*Classification*

There are three different motoric subtypes of delirium: hyperactive, hypoactive and mixed. Criteria for each category was defined by Meagher et al as follows [27]: Patients were classified as the "hyperactive" subtype (A) if they had three or more of the following: hypervigilance, restlessness, fast or loud speech, anger or irritability, combativeness, impatience, uncooperativeness, swearing, singing, laughing, euphoria, wandering, easy startling, distractibility, nightmares, persistent thoughts. This subtype is the most easily recognized form though may not be the most common. In a study by Meagher et al, mixed was reported to be the most common subtype (46%), followed by hyperactive (30%), with hypoactive being the least common (24%). Patients were classified as the "hypoactive" subtype (B) if they had four or more of the following: unawareness, decreased alertness, sparse or slow speech, lethargy, decreased motor activity, staring, apathy. Patients were classified as "mixed" subtype if they met the criteria for both (A) and (B) above. Determining the specific subtype may be important in assessing prognosis as the hyperactive profile has been found to be associated with shorter hospital length of stay (LOS) and more favorable outcomes compared to the hypoactive and mixed subtypes. This may be attributed to the hyperactive patients receiving more attention and hence, better therapeutic care, or it may also be a result of the hyperactive patients having the physical ability to become agitated.[28]

*Assessment of Delirium*

There are many diagnostic tools for assessing the presence or absence of delirium. One modality frequently used is the Confusion Assessment Method (CAM) score[29], which when modified for use in the ICU is known as the CAM-ICU score. The CAM-ICU assesses four separate components of delirium. It defines delirium as (1) acute onset of changes in the course of mental status, (2) inattention, as well as one of (3) an altered level of consciousness or (4) disorganized thinking. This tool was extrapolated from the traditional CAM score in order to allow evaluation of mechanically ventilated patients. The CAM-ICU has been shown to have excellent validity, reliability, as well as interrater reliability. It is also relatively easy to perform[12] with many widely available training tools to aid ICU caregivers.

*Study Purpose*

The reported incidence of delirium is highly variable, varying greatly between institutions. Although there is an empirical general perception of the occurrence of delirium within our own institutional cardiac surgical program, the overall incidence within the Winnipeg Regional Health Authority (WRHA) cardiac sciences program has not been well described. For example, in an earlier study performed by our group, the incidence of delirium was determined to be 6.9%.[30] However, this study was significantly limited in that it retrospectively identified patients as having delirium only if they had received psychotropic medication (ex. haloperidol) to treat its occurrence and as a result, included only those patients with the most severe hyperactive subtype of the disease. Although there are many aspects of the ICU that can contribute to its development, one of the potentially modifiable factors relates to the environment in which patients are being cared for. Specific environmental factors that can influence sleep-wake cycles are important. Accordingly, quiet private rooms with ready access to natural light are thought to reduce ICU sleep deprivation.[23] As a result of the creation of a new postoperative ICU with an improved physical environment within our institution, we had a unique opportunity to examine the impact of this factor on postoperative delirium in our patient population.

***Study Objective:*** The overall purpose of our study was to determine the incidence of post-cardiac surgery delirium, as well as to determine the impact of various environmental factors such as the location and design of the ICU.

## Materials and Methods

We conducted a retrospective chart review, collecting data on two cohorts of patients having undergone cardiac surgery in the WRHA (St. Boniface Hospital) cardiac sciences program. Institutional Research Ethics Board approval for the study was obtained and the requirement for patient consent was waived. Information collected included patient demographics, pre-operative comorbidities, and intra-operative variables, as well as post-operative complications (See Appendix 1 for the complete clinical report form). These variables and complications were analyzed to determine their association with delirium.

Two different patient cohorts were examined comprising individuals having had cardiac surgery from May 1, 2010 to June 15, 2010 (environment #1; E1) and May 1, 2011 to June 15, 2011 (environment #2; E2). Between these two time periods studied, a new cardiac surgical ICU was opened (April 2011), providing a unique opportunity to study the impact of several potential postoperative environmental risk factors for delirium. In the ICU during E1, patients were transferring from the OR to a dedicated specialized ICU with a 24-hour consultant in-house care. This ICU (E1) was in the middle of the main hospital building, with the lack of physical barriers between bed-spaces, high traffic noise and lack of exposure to natural light. In the new ICU (E2), each patient had a private room with outside windows, which not only reduced the extraneous noise level at the bedside, but also allowed the natural light to facilitate restoration of normal sleep/wake cycles. Thus, in addition to determining the overall incidence of delirium during the cumulative study time periods, a comparison was also made between the two time periods to evaluate the importance of potentially modifiable environmental risk factors.

The consecutively enrolled patients had assessments for delirium performed routinely on a 12 hourly basis using the Confusion Assessment Method (while on the ward) or CAM-ICU (while in the ICU).[31] The assessment was performed for up to seven days in the ICU and up to seven days on the postoperative hospital ward to determine the presence or absence of delirium. All statistical analyses were performed using SAS (SAS version 9.2, SAS Institute; Cary, NC). Data are presented as mean ± standard deviation. Binary outcome variables were defined for any positive delirium event occurring throughout the patient's stay in the ICU, general hospital ward or either of the two. Patients having delirium were compared to those without delirium with respect to their demographic and other perioperative parameters (Table 1). Univariate logistic regression was performed on covariates to identify different predictors of experiencing delirium post-cardiac surgery. Odds ratios were calculated and reported for the predictors having a $p < 0.10$. A multivariable logistic regression model was determined using a stepwise selection process that included variables having a univariate $p < 0.10$. The variables included advanced age, preoperative statin use, type of operation [coronary artery bypass graft (CABG) and aortic valve replacement], extubation in the operating room, cardiopulmonary bypass (CPB) time, hypertension and lowest serum sodium.

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## Results

Three hundred and one patients had cardiac surgery during the two time periods studied. One patient was excluded because their operation did not take place at St. Boniface Hospital and two other patients were excluded as they were still in hospital during the time of data analysis. The remainder of the patients excluded (n=12) had unrecorded delirium data, either in the ICU, on the ward or both. In total 286 patients were included in the final analysis. Patients were 66.8 ± 11.8 years with the majority of patients being male (69.6%). The most common surgical type was CABG (73.7%), followed by aortic valve replacement (23.2%) and other miscellaneous operations (3.1%). The average length of ICU and hospital stay was 4.8 ± 30.9 and 8.9 ± 31.7 days respectively.

Of the 286 patients analyzed, 44 patients (15.4%) had at least one episode of delirium at any time while in hospital. When comparing the two cohorts, 29 out of 151 patients (19.2%) developed delirium during their hospital stay in the E1 cohort compared to only 15 of 120 patients (11.1%) in the E2 cohort ($p = 0.0582$). When comparing the two cohorts specifically for the rates of delirium only in the ICU, 19 patients out of 152 (12.5%) had delirium in the E1, whereas 11 out of 138 patients (8.0%) were delirious in the E2 unit (p-value = 0.206).

From the univariate analysis, we chose characteristics with a $p < 0.10$ to be included in the multivariable analysis. The univariate risk factors (Table 1) identified for developing delirium included hypertension: 2.12 Odds Ratio (OR), 0.86 – 5.27 95% Confidence Interval (CI); $p = 0.0981$, preoperative statin use (1.99 OR, 0.91-4.35 95% CI; $p = 0.0787$), CABG surgery (2.54 OR, 1.03 – 6.28 95% CI; $p = 0.0378$), aortic valve surgery (1.92 OR, 0.96 – 3.84 CI; $p = 0.0638$), advanced age (1.55 OR, 1.11 – 2.17 95% CI; $p = 0.0105$), prolonged CPB time (1.07 OR, 1.01 – 1.14 95% CI, $p = 0.0238$), and lowest serum sodium during surgery (2.26 OR, 0.86 – 5.98 95% CI; $p = 0.0996$). Extubation in the OR proved to be protective against delirium (0.24 OR, 0.10 – 0.59 95% CI; $p = 0.0009$).

In the multivariable model, age continued to be a significant risk factor for any delirious event following cardiac surgery (1.59 OR for each 10 year increase in age, 1.12 -2.25 95% CI; $p = 0.0094$). As well, those patients that were extubated in the OR were far less likely to experience delirium (0.24 OR, 95% CI of 0.10 – 0.58; $p = 0.0018$). We also examined and determined the patient characteristics for delirium in the ICU versus delirium on the ward using multivariate analysis. Patients in the ICU had the following factors associated with delirium: advanced age (1.95 OR, 1.23 – 3.11 95% CI; $p = 0.0046$), prolonged CPB time (1.09 for each 10 minute increase in CPB time, OR, 1.01 – 1.18 95% CI; $p = 0.0361$), and visual impairment (0.42 OR, 0.17 – 1.06 95% CI; $p = 0.0663$). Conversely, patients on the ward had the following factors associated with delirium: preoperative statin use (3.92 OR, 1.13 – 13.63 95% CI; $p = 0.0319$) and extubation in the OR (0.20 OR, 95% CI: 0.06 – 0.71; $p = 0.0123$).

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## Discussion

Our study identified several univariate risk factors for delirium: hypertension, preoperative statin use, CABG surgery, aortic valve surgery, advanced age, prolonged CPB time and lowest sodium value during surgery. Extubation in the OR was associated with a lower incidence of delirium. However, only age and lack of extubation in the OR (i.e. need for prolonged ventilation support) remained significant risk factors in our multivariate model. Furthermore, environmental factors appeared to be a clinically important issue in the occurrence of delirium with 19.2% of E1 ICU patients experiencing at least one episode of delirium compared to the incidence of 11.1% in the enhanced (i.e. privacy, reduced noise, and natural light) E2 ICU, however, did not quite reach statistical significance, likely secondary to sample size. Since the two patient populations had similar demographics and intraoperative characteristics, the reduction in delirium supports that environmental settings play a significant role in the development of delirium.

The incidence of delirium that we report is comparable to that seen in previous post-cardiac surgery studies. Recent studies have reported the incidence following cardiac surgery to range from 13.5% to 41.7%.[25] Furthermore, a recent review article by Koster et al reported 27 risk factors for delirium following cardiac surgery have been identified. Our patient population was screened for most of these risk factors, but many of them were not found to be significant. These included postoperative infection, atrial fibrillation, depression, diabetes, history of stroke, intraaortic balloon pump use, peripheral vascular disease, pre- or postoperative cardiogenic shock, prolonged inotropic support and urgent operation. Although we found several univariate risk factors for delirium (including hypertension, preoperative statin use, CABG and aortic valve surgeries, extubation in the OR, advanced age, prolonged CPB time and lowest serum sodium), our multivariable analysis revealed only age and extubation in the OR to remain significant independent risk factors for any delirium. Age, CPB time and visual impairment were significant for ICU delirium and lack of extubation in the OR and preoperative statin use were significant for ward delirium.

The finding of a difference between the patients cared for postoperatively in the different ICUs suggests a potentially important impact of environment on delirium incidence. Compared to our E1 ICU, the E2 environment possessed private rooms with outside windows to allow in natural light. The results from our study suggest that in the future, ICUs should be designed to better simulate a natural environment. Individual patient rooms with windows allowing in natural light play a significant role in restoring sleep-wake cycles. This improves patient outcomes and in turn, may contribute to a decrease in healthcare costs.

There are limitations that should be considered when interpreting the results from this study. Firstly, since the data was collected from patient records as a retrospective chart review, variations in charting created difficulties when extracting data. For example, general limitations of chart reviews included incomplete documentation, difficulty recovering information, as well as missing data from the charts. In the initial 301 patients, we had 12 charts that had missing data; we did not include these patients in our analysis. Another limitation is the relatively small sample size ($n = 286$). Although there was a clinically significant reduction in the incidence of delirium from the first cohort to the second, this did not quite reach statistical significance ($p = 0.0582$). However, had a larger sample been used, it likely would have been significant had this trend continued. Ongoing delirium data within the cardiac sciences program collection continues with the intent of at least doubling the sample size. Another possible limitation is an "era" effect. We cannot exclude the impact that awareness and education of delirium by the bedside registered nurses and medical staff could have on clinical practice. There was not, however, any formalized intervention strategies other than current standards of practice during the time period studied. Furthermore, we intentionally started data collection for the E1 cohort after an ample time for education of the clinical care-giver team to minimize this potential effect. Similarly, data collection for E2 started after 30 days following the opening of the new ICU and postoperative ward.

Interestingly, while visual impairment is usually reported to be a risk factor for the development of delirium,[32] in our study a lack of visual impairment appeared to be a significant risk factor. We defined visual impairment as any deviation from normal vision, from reading glasses through to more serious visual loss associated with diabetes and macular degeneration. This very broad definition of visual impairment makes interpretation of this information difficult. A better quantification of visual impairment would have been useful. Preoperative statin use was also a risk factor that we described. The use of statins has previously been reported as both having a negative and positive effect on the development of delirium. In 2008, Redelmeier et al reported that statin use was associated with an increased risk of postoperative delirium among elderly patients undergoing elective surgery.[33] However in 2009, Katznelson a prospective study demonstrated the statins were protective when examining their effect on delirium after cardiac surgery.[34] In our study, preoperative statin use trended towards being a risk factor for delirium (p-value = 0.0981).

*Future Directions*

The clinical report form used for this retrospective chart review will be implemented in several centers across Canada as part of a proposed prospective study. While beyond the scope of the B.Sc. Medicine Program, the future goal of this study is to establish a nationwide registry of the incidence of post-cardiac surgery delirium, as well as to implement environmental changes into ICUs across Canada in order to reduce this incidence and decrease healthcare costs.

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Table 1: Univariate Results of Patient and Perioperative Characteristics in Those With and Without Delirium*

| **Study Variables** | **Any Delirium (N=44)** | **No Delirium (N=42)** | **Total Population (N=286)** | **P-value (Comparing Delirium with non-Delirium)** |
|---|---|---|---|---|
| **Hypertension** | 37 (86.1%) | 180 (74.4%) | 217 (76.1%) | 0.0981** |
| **Preoperative Statin Use** | 35 (79.6%) | 156 (66.1%) | 191 (68.2%) | 0.0787** |
| **CABG** | 38 (86.4%) | 172 (71.4%) | 210 (73.7%) | 0.0378** |
| **Aortic Valve** | 15 (34.1%) | 51 (21.3%) | 66 (23.2%) | 0.0638** |
| **Extubation in OR** | 6 (13.6%) | 95 (39.8%) | 101 (35.7%) | 0.0009** |
| **Age** | 70.8 (8.4%) | 65.9 (12.2) | 66.6 (11.8) | 0.0105** |
| **CPB Time** | 112.5 (91.5 – 151) | 94 (73 – 128) | 97 (74 – 134) | 0.0238** |
| **Lowest Na** | 133 (132 – 134.5) | 133 (131 – 135) | 133 (131 – 135) | 0.0996** |
| Gender (Female) | 13 (29.6%) | 72 (30.5%) | 85 (30.4%) | 0.8985 |
| Diabetes | 17 (40.5%) | 81 (33.8%) | 98 (34.8%) | 0.3984 |
| Atrial Fibrillation | 6 (14.0%) | 27 (11.3%) | 33 (11.7%) | 0.6179 |
| PVD | 4 (9.3%) | 19 (8.0%) | 23 (8.2%) | 0.7655 |
| COPD | 2 (4.7%) | 23 (9.6%) | 25 (8.9%) | 0.2910 |
| OSA | 4 (9.1%) | 20 (8.3%) | 24 (8.5%) | 0.8681 |
| Cardiogenic Shock | 0 (0.0%) | 7 (2.9%) | 7 (2.5%) | 0.2558 |
| Cerebrovascular Disease | 6 (14.0%) | 24 (10.0%) | 30 (10.6%) | 0.4380 |
| Impaired Cognition | 1 (2.3%) | 0 (0.0%) | 1 (0.4%) | 0.3358 |
| Other Psychiatric | 8 (15.1%) | 36 (18.6%) | 44 (15.6%) | 0.5557 |
| Visual Impairment | 15 (36.6%) | 111 (46.8%) | 126 (45.3%) | 0.2235 |
| Current Smoker | 6 (14.6%) | 34 (14.5%) | 40 (14.6%) | 0.9861 |
| Past Smoker | 29 (69.1%) | 143 (60.3%) | 172 (61.7%) | 0.2846 |
| Preoperative Benzodiazepines | 3 (7.0%) | 22 (9.4%) | 25 (9.1%) | 0.6048 |
| Preoperative Antidepressant | 4 (9.3%) | 15 (6.4%) | 19 (6.9%) | 0.4954 |
| Ejection Fraction <= 35% | 8 (18.2%) | 41 (16.9%) | 49 (17.1%) | 0.8409 |
| 35 < Ejection Fraction < 50 | 5 (11.4%) | 21 (8.7%) | 26 (9.1%) | 0.5686 |
| Preoperative Ketamine | 21 (47.7%) | 118 (49.6%) | 139 (49.3%) | 0.8214 |
| Preoperative Midazolam | 29 (65.9%) | 178 (74.2%) | 207 (72.9%) | 0.2573 |
| Preoperative Morphine | 13 (29.6%) | 80 (33.5%) | 93 (32.9%) | 0.6103 |
| Preoperative Neostigmine | 6 (13.6%) | 55 (23.0%) | 61 (21.6%) | 0.1645 |
| Preoperative Steroids | 5 (11.4%) | 29 (12.2%) | 34 (12.1%) | 0.8779 |
| Antifibrinolytic | 35 (79.6%) | 192 (80.0%) | 227 (79.9%) | 0.9448 |
| Spinal Anesthesia | 1 (2.4%) | 7 (3.0%) | 8 (2.9%) | 0.8281 |
| Return to OR for bleeding | 4 (9.1%) | 26 (10.9%) | 30 (10.6%) | 0.7233 |
| Creatinine | 87 (73 - 110) | 84 (71 - 98.5) | 84.5 (71 - 100) | 0.3352 |
| Preoperative Hb | 138 (120 - 146) | 135 (124 - 147) | 136 (124 - 146) | 0.7144 |
| Highest Glucose | 9 (7.7 - 9.5) | 8.8 (7.7 - 10.1) | 8.9 (7.7 - 9.9) | 0.9829 |

*Numbers that do not add up to the total (n=286) reflect missing values for certain variables.
**Significant variables at the $p < 0.10$ level
PVD = Peripheral Vascular Disease
COPD = Chronic Obstructive Pulmonary Disease
OSA = Obstructive Sleep Apnea

Table 2: Multivariable Logistic Models of Delirium in Cardiac Surgery Patients

**CAM Assessment for Any Postoperative Delirium**

| Risk Factor | Odds Ratio | 95% Confidence Interval | P-Value |
|---|---|---|---|
| Age (10 Year Increase) | 1.59 | (1.12 - 2.25) | 0.0094 |
| Extubation in OR | 0.24 | (0.10 - 0.58) | 0.0018 |

**CAM Assessment for Delirium in the ICU**

| Risk Factor | Odds Ratio | 95% Confidence Interval | P-Value |
|---|---|---|---|
| Age (10 Year Increase) | 1.95 | (1.23 - 3.11) | 0.0046 |
| CPB Time (10 Minute Increase) | 1.09 | (1.01 - 1.18) | 0.0361 |
| Visual Impairment | 0.42 | (0.17 - 1.06) | 0.0663 |

**CAM Assessment for Delirium on the Ward**

| Risk Factor | Odds Ratio | 95% Confidence Interval | P-Value |
|---|---|---|---|
| Extubation in OR | 0.20 | (0.06 - 0.71) | 0.0123 |
| Preoperative Statin Agent Use | 3.92 | (1.13 - 13.63) | 0.0319 |

CAM = Confusion Assessment Method
OR = Operating Room
CPB = Cardiopulmonary Bypass Time

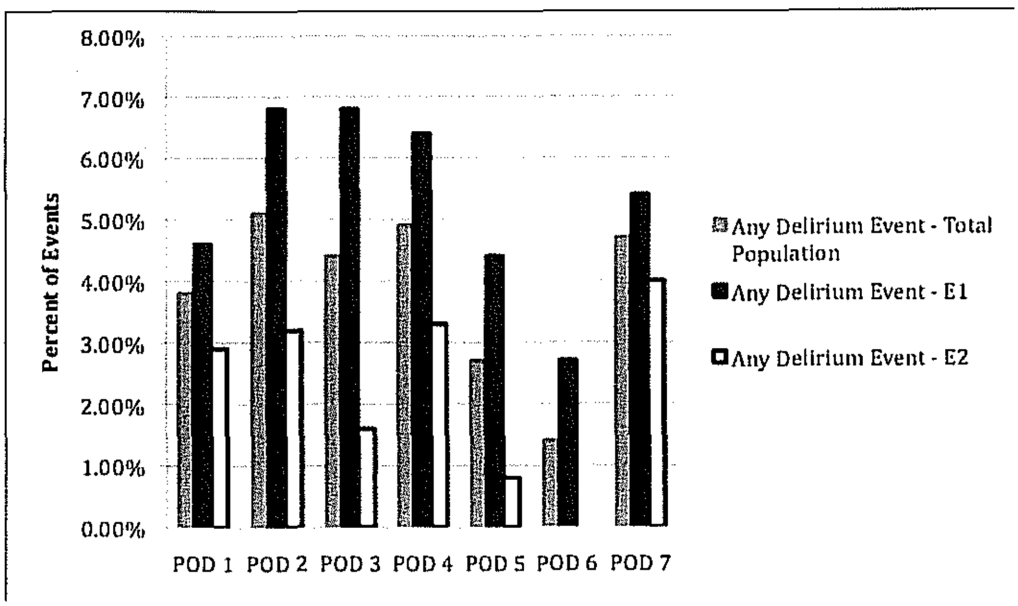


Figure 1: Delirium Prevalence
POD = Postoperative Day

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## Appendix 1: Clinical Report Form

### Post-Cardiac Surgery Delirium: incidence and risk factors
### Case Report Form

**Patient Identifiers**

**Hospital ID#:** ____________ **Study#:** ________

**Patient Initials** ______ (First Last)

**Sex:** M (1) F (2) **Age:** ____ yrs **Surgical date** (mm/dd/yyyy) ________

**Pre-operative factors:**

| | | |
|---|---|---|
| Frailty Score (independence) | (Circle one) | |
| • Feeding | Y (1) N (2) | |
| • Dressing | Y (1) N (2) | |
| • Toileting | Y (1) N (2) | |
| • Bathing | Y (1) N (2) | |
| • Transferring (bed to chair) | Y (1) N (2) | |
| • Continence (bladder) | Y (1) N (2) | |
| • Ambulatory | Y (1) N (2) | |
| • Ambulatory w/o assistance | Y (1) N (2) | If no, type of assist device: ________ |
| Documented Dementia | Y (1) N (2) | |
| Hypertension | Y (1) N (2) | |
| Diabetes Mellitus | Y (1) N (2) | |
| Atrial Fibrillation | Y (1) N (2) | |
| Peripheral Vascular Disease | Y (1) N (2) | |
| COPD | Y (1) N (2) | |
| USA | Y (1) N (2) | |
| Cardiogenic Shock (Pre-op inotrope, vasopressor, IABP) | Y (1) N (2) | |
| Cerebrovascular Disease (Stroke, TIA) | Y (1) N (2) | |
| Other Structural Brain Disease (Tumor, SAH, seizures) | Y (1) N (2) | |
| Impaired Cognition (Early Alzheimers, MCI) | Y (1) N (2) | |
| Other Psychiatric (Depression, Anxiety) | Y (1) N (2) | |
| Visual Impairment | Y (1) N (2) | If yes, describe: ________ |
| Hearing Impairment | Y (1) N (2) | |
| Smoking: Current Y (1) N (2) Past | Y (1) N (2) | If yes, # of pack years: ________ |
| Alcohol Consumption | ______ # of drinks per week | |
| Drug Abuse | Y (1) N (2) | |
| Spinal (1) /Epidural (2) anesthetic | (if yes, circle one) N (3) | |
| Extubation in OR | Y (1) N (2) | |

**Labs:**

| | | |
|---|---|---|
| Lowest Hemoglobin | ______ | g/L |
| Highest Glucose | ______ | mmol/L |
| Lowest $Na^+$ | ______ | mmol/L |

| | | | |
|---|---|---|---|
| Pre-operative Benzodiazepine | Y (1) N (2) | | **List of Medications** |
| Pre-operative Antipsychotic | Y (1) N (2) | | ________ |
| Pre-operative Antidepressant | Y (1) N (2) | | ________ |
| Pre-operative Statin agent used | Y (1) N (2) | | ________ |
| Log EuroSCORE | ______ | % | ________ |
| Ejection Fraction | ______ | % | ________ |
| Creatinine | ______ | µmol/L | ________ |
| Glucose | ______ | mmol/L | ________ |
| Hemoglobin | ______ | g/L | ________ |
| HbA1c (% of total Hb) | ______ | % | ________ |

**Intra-operative factors**

Operation Type:

☐ Emergent Salvage (1) ☐ Emergent (2) ☐ Urgent (3) ☐ Elective (4) (Check one)

| | | |
|---|---|---|
| OPCAB | Y (1) N (2) | |
| CABG | Y (1) N (2) | # of Grafts ______ |
| Mitral Valve | Y (1) N (2) | |
| Aortic Valve | Y (1) N (2) | |
| Tricuspid Valve | Y (1) N (2) | |
| Ascending Aorta | Y (1) N (2) | |
| Arch | Y (1) N (2) | |
| Descending Aorta | Y (1) N (2) | |
| DHCA | Y (1) N (2) | Length. ______ mins |
| SACP | Y (1) N (2) | Length. ______ mins |
| Redo-sternotomy | Y (1) N (2) | |
| Other Procedure | Y (1) N (2) | Explain. ________ |
| Incision Time | | ______ (24-hr clock) |
| Closure Time | | ______ (24-hr clock) |
| CPB Time (Total) | | ______ mins |
| Aortic Cross-clamp Time (Total Ischemic Time) | | ______ mins |

| Drugs used: | | Dosage (mg) | Drugs used: | | Dosage (mg): |
|---|---|---|---|---|---|
| Sevoflurane | Y (1) N (2) | | Glycopyrrolate | Y (1) N (2) | ______ |
| Isoflurane | Y (1) N (2) | | Ketamine | Y (1) N (2) | ______ |
| Desflurane | Y (1) N (2) | | Midazolam | Y (1) N (2) | ______ |
| Atropine | Y (1) N (2) | ______ | Morphine | Y (1) N (2) | ______ |
| Clonidine | Y (1) N (2) | ______ | Neostigmine | Y (1) N (2) | ______ |
| Dexmedetomidine | Y (1) N (2) | ______ | Steroids | Y (1) N (2) | ______ |
| Fentanyl | Y (1) N (2) | ______ | Sufentanil | Y (1) N (2) | ______ |
| Gabapentin | Y (1) N (2) | ______ | Anti-fibrinolytic (TXA) | Y (1) N (2) | ______ g/mL |

**Post-operative Factors:**

Extubation Time ______ Date: ______ ICU Arrival Time ______ Date: ______

| | | |
|---|---|---|
| ICU Re-admission | Y (1) N (2) | |
| Reintubation | Y (1) N (2) | |
| Return to OR | Y (1) N (2) | If yes, reason. ________ |
| Inotrope/Vasopressor/IABP >24 hours | Y (1) N (2) | |
| Statin agent used | Y (1) N (2) | |
| Atrial Fibrillation | Y (1) N (2) | |
| Ventricular Arrhythmia | Y (1) N (2) | If yes, type: ________ |
| Dialysis (Renal Failure) | Y (1) N (2) | |
| Stroke | Y (1) N (2) | |
| TIA | Y (1) N (2) | |
| Severe Encephalopathy/Coma | Y (1) N (2) | |
| USA | Y (1) N (2) | |
| Infection | Y (1) N (2) | If yes, site: ________ |
| Sepsis | Y (1) N (2) | |

First Positive Blood Culture Date: ______ Time: ______ Organism: ________

| | | |
|---|---|---|
| Highest Creatinine | ______ | µmol/L |
| Lowest $Na^+$ | ______ | mmol/L |
| Transfusion (intra- and/or post-operative) | Y (1) N (2) | |
| • RBC | Y (1) N (2) Amount. ______ | units |
| • FFP | Y (1) N (2) Amount. ______ | units |
| • Platelets | Y (1) N (2) Amount. ______ | units |
| • Cryoprecipitate | Y (1) N (2) Amount. ______ | units |

Post-operative Neuro-imaging:

| | |
|---|---|
| • CT Scan | Y (1) N (2) |
| • MRI | Y (1) N (2) |
| • EEG | Y (1) N (2) |

**Delirium Identification:**

ICU (ICCS)

| | Surgical Date (ICU day 0) | ICU day 1 (POD 1) | ICU day 2 | ICU day 3 | ICU day 4 | ICU day 5 | ICU day 6 | ICU day 7 | ICU D/C Date |
|---|---|---|---|---|---|---|---|---|---|
| RASS Score | | | | | | | | | |
| CAM +ve Yes (1) No (2) | | | | | | | | | |
| Date (mm/dd/yyyy) | | | | | | | | | |
| | | | | | | | | Time: | |

Ward (CSIU)

| | Ward Admit Date (Ward day 1) | Ward day 2 | Ward day 3 | Ward day 4 | Ward day 5 | Ward day 6 | Ward day 7 | Hospital D/C Date |
|---|---|---|---|---|---|---|---|---|
| CAM +ve Yes (1) No (2) | | | | | | | | |
| Date (mm/dd/yyyy) | | | | | | | | |

| | | | |
|---|---|---|---|
| Any Incident of Delirium (CAM +ve) in ICU | Y (1) N (2) | Any Incident of Delirium (CAM +ve) Post-ICU | Y (1) N (2) |
| Time of first Delirium Incident (24-hour clock) | ______ | # of Delirium Days after Post-operative Day 7 | ______ |
| Delirium Drug Therapy | Y (1) N (2) | Agent | ________ |
| Required Constant care | Y (1) N (2) | | |

Discharge to Home (without help) Y (1) N (2) If no, disposition (check one)

☐ Home w/ help (1)
☐ Convalescence or Rehab centre (temporary) (2)
☐ Nursing home (permanent) (3)
☐ Other (4)

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