Transient advanced mental impairment: An underappreciated morbidity after aortic surgery

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Objectives: **To determine the incidence, risk factors, and associated morbidity of transient advanced mental impairment (TAMI) after aortic surgery.**
Methods: **We retrospectively studied the charts of 188 consecutive patients undergoing elective aortic reconstruction during a recent 6-year period at a university hospital. All patients were lucid on admission and nonintubated at the time of evaluation at least 2 days after operation. *TAMI* was defined as disorientation or confusion on 2 or more postoperative days. Preoperative, intraoperative, and postoperative clinical variables were examined statistically for associations with TAMI.**
Results: **Fifty-three patients (28%) had development of TAMI 3.9 ± 2.8 days after operation. Stepwise logistic regression analysis selected the following independent predictors for TAMI: age >65 years (odds ratio [OR], 7.9; 95% confidence interval [CI], 2.7 to 23.7), American Society of Anesthesiology physical status classification >3 (OR, 2.8; 95% CI, 1.3 to 5.9), diabetes mellitus (OR, 3.4; 95% CI, 1.2 to 9.8), old myocardial infarction (OR, 2.4; 95% CI, 1.1 to 5.3), and hypertension (OR, 2.3; 95% CI, 1.0 to 5.3). Alcohol consumption was not significantly associated with TAMI. In the postoperative period, patients with TAMI were more likely to have hypoxia ($P < .001$), a need for reintubation ($P < .001$), pneumonia ($P < .001$), congestive heart failure ($P = .003$), and kidney failure ($P = .05$). In addition, patients with TAMI had a longer duration of endotracheal intubation (3.7 ± 7.8 vs 0.6 ± 1.2 days, $P < .001$), stay in the intensive care unit (8.9 ± 9 vs 3.9 ± 2 days, $P < .001$), and postoperative hospital stay (14.8 ± 11 vs 9.2 ± 5 days, $P < .001$) than patients without TAMI. Twenty (38%) patients with TAMI were discharged to intermediate-care facilities, compared with 11 (8%) patients without TAMI ($P < .001$). Postoperative variables conferring the largest relative risks for development of TAMI included oxygen saturation less than 92% (5.4), the need for reintubation (3.3), congestive heart failure (3.3), and pneumonia (3.2). TAMI, conversely, conferred the largest relative risks for development of postoperative congestive heart failure (15.3), the need for reintubation (9.3), pneumonia (7.1), and the need for ICU readmission (3.8).**
Conclusions: **These data show that TAMI is prevalent among patients undergoing aortic reconstruction and is associated with dramatically increased morbidity and postoperative hospitalization rates. (J Vasc Surg 2002;35:376-81.)**

Nonspecific terms used to describe delirium include "ICU psychosis," "acute confusional state," "metabolic encephalopathy," and "toxic brain syndrome." However, delirium is a specific diagnosis whose criteria are best documented with testing instruments developed for this purpose.[1,2] According to the Diagnostic and Statistical Manual of Mental Disorders, 4th Edition (DSM-IV), delirium is a disturbance of consciousness with a reduced ability to focus, sustain, or shift attention.[3] There is a change in cognition (memory deficit, disorientation, or language disturbance) or the development of a perceptual disturbance that is not accounted for by preexisting dementia. Delirium develops typically over a short period and tends to fluctuate over the course of a few days. Finally, there is evidence from the history, physical examination, and diagnostic test results that the disturbance is caused by the physiological consequences of a medical condition. Prospective assessment with frequent patient interviews and psychiatric testing are desirable for high sensitivity and specificity in making this diagnosis.[3]

Postoperative delirium may be a significant complication after cardiothoracic surgery involving cardiopulmonary bypass or circulatory arrest,[4-9] major orthopedic surgery,[10-14] and revascularization procedures for chronic lower limb ischemia.[15] In a large prospective study of 1341 patients undergoing elective, major non-heart-related pro-

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cedures, aortic aneurysm repair was found to be an independent correlate with postoperative delirium.[16]

We hypothesized that delirium was a frequent complication in patients undergoing aortic surgery. Furthermore, we believed that this complication often coexisted with other major complications and was associated with prolonged recovery. To gain insight into this problem, we retrospectively reviewed data in patients undergoing aortic surgery. Because it was not possible to fulfill retrospectively the specific DSM-IV criteria for delirium, we chose a surrogate marker that we termed *transient advanced mental impairment* (TAMI).

MATERIAL AND METHODS

TAMI was defined as disorientation or confusion in an extubated or conversant patient occurring on 2 or more days within postoperative days (POD) 2 to 14. POD 1 was excluded to better distinguish TAMI from the residual effects of anesthesia. The occurrence of disorientation, confusion, altered level of consciousness (lethargic, somnolent, obtunded, hypervigilant), delusions, hallucinations, or agitation was recorded for each patient. Postoperative time of onset, duration of TAMI, and the need for physical restraints were ascertained.

All patients underwent aortic reconstruction on the vascular surgery service at a single university teaching hospital from September 1993 (initiation of a modern data-entry program for operative cases at this hospital) through July 1999 (time of generation of list for patient-chart review). Procedures included consecutive repair of all aneurysms and dissections involving the descending thoracic, thoracoabdominal, and abdominal aorta; thromboendarterectomy of the abdominal aorta (with or without iliac involvement); bypasses from the aorta to the iliac or femoral arteries with synthetic or autogenous material; and complete removal of infected aortic grafts. Emergency operations and endovascular aortic procedures were excluded. Of 200 patients identified, 196 charts were available for review. Demographic face sheets, history and physical, physician progress notes, nursing assessment sheets, nursing progress notes, and intensive care unit (ICU) flow sheets were extensively reviewed.

Inclusion criteria were as follows. All patients had to (1) demonstrate orientation to person, place, and time on preoperative assessment; (2) demonstrate basic preoperative understanding of the procedure; (3) be able to give informed consent; and (4) have a period when they were extubated and able to communicate orally during POD 2 through 14. Patients excluded from analysis included five who died without being extubated or who died before postoperative day 2, two who were initially extubated after postoperative day 14 and thus were intubated during the entire study period, and one who was deemed demented and confused during the initial evaluation.

Preoperative data that were examined included presence of the following laboratory abnormalities: hematocrit <35%, anemia requiring preoperative blood transfusions, white blood cell count >12,000 or <5000/mm^3, serum sodium >150 or <130 mEq/dL, serum potassium >6 or <3 mEq/dL, serum glucose >300 or <60 mg/dL, serum albumin <3.5 g/dL, urinalysis revealing >5 white blood cells per high-power field or greater than trace leukocyte esterase or nitrite positivity, and evidence of malnutrition. Malnutrition was defined as less than 90% of ideal body weight, evidence of recent weight loss greater than 10%, or serum albumin <3.5 g/dL. American Society of Anesthesiology (ASA) physical status classifications[17] were obtained on all patients from preanesthetic assessment forms.

The types of operations were recorded, and the performance of combined procedures was noted. A combined procedure was defined as an aortic reconstruction combined with an infrainguinal, renal, or visceral revascularization. The level of aortic cross-clamp placement was noted. Data obtained from anesthesia records included duration of surgery; presence of a drop in blood oxygen saturation (SaO_2) to less than 90%; evidence of hypotension defined as a drop in systolic pressure to less than 90 mm Hg or less than 66% of baseline systolic pressure obtained before induction of anesthesia; evidence of hypothermia defined as core temperature less than 35.5° C; volumes of infusions of crystalloid and colloid; number of infused units of packed red blood cells, fresh frozen plasma, platelets, and cryoprecipitate; volume of cell saver blood reinfused; and estimated blood loss.

Events occurring on POD 1 through 7 were recorded and included fever (temperature >39° C), hypoxia (SaO_2 < 92 mm Hg), need for pressors or inotropes, hematocrit <30%, serum sodium >150 or <130 mEq/dL, serum potassium >6 or <3 mEq/dL, glucose >300 or <60 mg/dL, and elevations in serum creatinine over preoperative values. Other variables examined were the number of postoperative blood transfusions required on POD 1 through 7, initial days spent intubated, need for reintubation, total days intubated, preoperative admission to the ICU, need for ICU readmission, and total days in the ICU. PODs were rounded off to the nearest 12-hour interval and began on arrival to the ICU. Also recorded was the use of patient-controlled analgesia (PCA) (either intravenous or epidural administration), epidural analgesia (either patient-controlled or nonpatient-controlled), number of days until the resumption of a normal diet, and need for reoperation during this period.

All postoperative complications were recorded. Congestive heart failure was defined as a fluid-overloaded state necessitating reintubation, readmission to the ICU, or pharmacologic support in the form of cardiac inotropes or pressors. Postoperative kidney failure was defined as a rise in creatinine of >0.5 mg/dL from the preoperative value. Death before hospital discharge was recorded, as was length of postoperative hospital stay. Discharge disposition was also ascertained (home, skilled nursing facility, or rehabilitation facility).

Statistical analyses were performed by use of a commercial software package (Statistical Analysis System for Windows version 6.12, SAS Institute, Inc, Cary, NC). Continuous data are expressed as mean ± SD. Comparisons among groups of unpaired data were performed by use of Student *t* test. The Mann-Whitney U test was used to examine the distribution assumptions when large standard deviations were encountered. Comparisons between categorical parameters were made by use of the χ^2 analysis with the Yates correction. These tests were used to test the association between all demographic, preoperative, and intraoperative clinical data and the end point of development of TAMI. To identify independent predictors of TAMI, multivariable analysis was performed on significant univariate factors by use of stepwise logistic regression. Univariate analysis was also used to test the association between all postoperative clinical data/complications and TAMI. Because these represented pure associations and not predictive factors, multivariable analysis was not performed for postoperative data. However, relative risks were generated on selected postoperative complications displaying significant associations with TAMI. Frequently, it was difficult to determine whether TAMI might be a cause or an effect of the postoperative complication in question. In these cases, relative risks were generated for both the probability for development of TAMI, given the presence of the complication; or the probability for development of the complication, given the presence of TAMI.

RESULTS

All patients. Of the 188 patients who satisfied the inclusion criteria, 133 were men (70.7%) and 55 were women (29.3%), with a mean age of 66 ± 10 years (range 31 to 91 years). Forty-one patients (21.8%) were actively employed at the time of operation. No patients were living in nursing care facilities. Six patients (3.2%) were legally blind, and 20 (10.6%) patients wore hearing aids. Five patients (2.7%) required foreign language translators to obtain informed consent. One hundred patients (53.2%) were in the active smoking group, and 69 patients (36.7%) were in the remote smoking group. Seventy patients (37.2%) were classified in the alcohol use group, and eight patients (4.3%) were in the heavy alcohol use group. Those in the alcohol use group regularly consumed at least 1 drink (1 ounce alcohol) per week. A subset of this group, which consumed at least 3 drinks (3 ounces alcohol) per day, was defined as the heavy alcohol use group. Fourteen patients (7.4%) admitted to a remote history of heavy alcohol use. Three patients (1.6%) were active users of illicit, recreational drugs. Eleven patients (5.9%) carried a diagnosis of a psychiatric illness requiring medication, and 58 patients (30.9%) were regularly taking either medication for psychiatric illness or medication known to have significant effects on the central nervous system. These medications included antidepressants, antipsychotics, sedatives, corticosteroids, xanthine derivatives, and H_2 blockers. Six patients (3.2%) had a diagnosis of mild dementia or Alzheimer's disease. They had varying degrees of short-term memory loss, were oriented to time and place, and were able to give informed consent. Nineteen patients (10.1%) had had a previous stroke, and one patient (0.5%) had a residual expressive aphasia. Six patients (3.2%) had had a transient ischemic attack within the previous 2 years.

Comorbidities among these patients included hypertension (defined as presently taking medication) (61.2%), diabetes (12.8%), coronary artery disease (48.4%), previous myocardial infarction (28.7%), cardiac arrhythmia (11.7%), congestive heart failure (7.4%), chronic obstructive lung disease (defined as presently receiving treatment or having a preoperative forced expiratory volume in 1 second of less than 2 l) (22.9%), chronic renal insufficiency (creatinine greater than 1.5) (13.3%), and dependence on kidney dialysis (2.1%). Eleven patients (5.9%) were being treated with thyroid hormone replacement therapy, and one patient (0.5%) had hyperthyroidism. A malnourished state was present in 14 patients (7.4%). Twenty-five patients (13.3%) were known to have had an infection within 2 weeks of surgery, and most of these had infected aortic grafts. Nine patients (4.8%) were categorized as ASA class 2, 105 (55.9%) as class 3, 73 (38.8%) as class 4, and 1 (0.5%) as class 5. No patients were categorized as ASA class 1.

The operative indication was aneurysm in 122 patients (64.9%), occlusive disease in 45 (23.9%), and infected graft/artery in 21 (11.2%). Forty-two patients had a tube-graft reconstruction of the infrarenal aorta, 58 had an aortobiiliac reconstruction or bypass of the infrarenal aorta, and 44 had a reconstruction or bypass of the infrarenal aorta, which involved either one or two femoral anastomoses. Three underwent repair of an aneurysm extending to the suprarenal aorta, nine underwent repair of a thoracoabdominal aneurysm, and 32 underwent autogenous reconstruction of the aortoiliac/femoral system with superficial-femoral-popliteal vein. Nineteen patients underwent a combined procedure with concomitant renal, visceral, or infrainguinal bypass. Aortic cross-clamp location was infrarenal in 137, suprarenal in 17, supramesenteric in 3, and supraceliac in 29 patients. Mean operative time was 293 ± 155 minutes. Estimated blood loss was 1640 ± 1800 mL, and transfusion requirements were 3.4 ± 4.2 units of packed red blood cells.

Patients with TAMI. TAMI occurred in 53 (28%) patients and was first documented 3.9 ± 2.8 days after surgery. Although the nursing staff noted evidence of TAMI in all 53 patients, physicians documented altered mental status in only 39 (74%) of the charts. Mean duration of TAMI was 5 ± 5.7 days, and 10 (5%) patients still manifested TAMI at the time of discharge. In characterizing TAMI, altered level of consciousness was documented in 27 patients, confusion in 51 patients, disorientation in 52 patients, delusions in 12 patients, and hallucinations in 13 patients. Severe agitation was reported in 40 patients, and restraints were required in 37 (70%) patients manifesting TAMI.

Univariate analysis of all demographic, preoperative, and intraoperative clinical data in relation to the development of TAMI are displayed in Table I (online only). In comparison to those with normal recovery, patients with TAMI were more likely to be older than age 65 years ($P < .001$); were less likely to be working ($P < .006$); were more likely to be in a group with ASA class >3 ($P < .001$);

had a higher incidence of old myocardial infarction (P < .003); malnourished state (P < .004); diabetes mellitus (P < .006); coronary artery disease (P < .01), and hypertension (P < .02). Patients with TAMI were also more likely to have an antecedent history of stroke (P < .05), mild dementia (P < .001), and use of medications with psychiatric side effects (P < .01). Of interest, neither regular nor heavy alcohol consumption was significantly associated with TAMI, nor were any of the operative variables including type and duration of aortic procedure.

Multivariable analysis of significant univariate predictors identified age >65 (P = .0002; odds ratio [OR], 7.9; 95% confidence interval [CI], 2.7 to 23.7), ASA > 3 (P = .008; OR, 2.8; 95% CI, 1.3 to 5.9), diabetes mellitus (P = .02; OR, 3.4; 95% CI, 1.2 to 9.8), previous myocardial infarction (P = .03; OR, 2.4; 95% CI, 1.1 to 5.3), and hypertension (P = .04; OR, 2.3; 95% CI, 1.0 to 5.3) as independent predictors of TAMI. This analysis generated a Homer & Lemeshow goodness-of-fit statistic of 1.89, df = 7, P = .97, which is consistent with an excellent fit.

Postoperative clinical data and complications and their association with the development of TAMI are displayed in Table II (online only). Postoperative univariate factors significantly associated with TAMI included postoperative hypoxia (P < .001), need for reintubation (P < .001), need for a postoperative blood transfusion (P = .008), pneumonia (P < .001), congestive heart failure (P = .003), and kidney failure (P = .05). Patients with development of TAMI received more postoperative blood transfusions (2.6 ± 2.6 vs 1.2 ± 1.4 units; P < .001), had a greater increase in their serum creatinine values (0.67 ± 1.3 vs .32 ± .83 mg/dL; P = .03), took longer to tolerate a diet (6.4 ± 2.6 vs 5.1 ± 2 days; P < .001), had a longer initial period of intubation (1.3 ± 2 vs 0.6 ± 0.9 days; P = .002), had a longer total duration of intubation (3.7 ± 7.8 vs 0.6 ± 1.2 days; P < .001), had a longer ICU stay (8.9 ± 9 vs 3.9 ± 2 days; P < .001), and had a longer postoperative hospital stay (14.8 ± 11 vs 9.2 ± 5 days; P < .001) than patients without development of TAMI. Because of the large standard deviations, the Mann-Whitney U test was used to examine the distribution assumptions. The results followed the same pattern found by the Student t test for unequal variances and thus confirmed significance. The use of either PCA (intravenous or epidural) or the use of epidural analgesia in any fashion after operation both showed a significant negative association with the development of TAMI. Factors approaching but not achieving significance were a need for ICU readmission and a postoperative hematocrit <30%. Twenty (38%) patients with TAMI were discharged to nursing homes or physical rehabilitation facilities, compared with 11 (8%) patients without TAMI (P < .001).

Relative risks for development of TAMI given the presence of selected postoperative variables or complications and relative risks of exhibiting a postoperative variable given the presence of TAMI are displayed in Table III (online only). An oxygen saturation less than 92%, the need for reintubation, and a postoperative course complicated by congestive heart failure or pneumonia conferred the largest relative risks (relative risks 5.4, 3.3, 3.3, and 3.2, respectively) for development of TAMI in the postoperative period. Conversely, the presence of TAMI conferred the largest relative risks for the development of congestive heart failure, the need for reintubation, pneumonia, and the need for ICU readmission in the postoperative period (relative risks 15.3, 9.3, 7.1, and 3.8, respectively).

DISCUSSION

The overall incidence of TAMI in this study was 28%. This finding is in agreement with prospective studies that used testing instruments specifically designed to fulfill the DSM-IV criteria for the diagnosis of postoperative delirium. Delirium occurred in 25% of patients after hypothermic circulatory arrest,[8] 32% after coronary artery bypass grafting,[6] and 28% after major orthopedic surgery.[10] Patients undergoing major vascular surgical procedures may be at special risk. Sasajima et al[15] found that 29% of patients undergoing major vascular surgery for chronic limb ischemia had development of postoperative delirium, and the incidence was highest among those with critical limb ischemia (56%) and those older than 70 years of age (42%).[15] Marcantonio et al[16] prospectively examined a large number of patients undergoing a wide variety of major, elective noncardiac operations and found a 9% incidence of postoperative delirium. The incidence of postoperative delirium was 46% in the subgroup undergoing aortic aneurysm repair. The value was higher than in any other subgroup.

In examining major series and overviews of patients undergoing aortic surgery, postoperative delirium is rarely, if ever, mentioned as a complication.[18-21] This is surprising when considering the adverse outcomes associated with this complication. In our study, 70% of patients with development of TAMI required physical restraints and extra nursing care. They spent significantly more time in the ICU, remained intubated longer, had longer hospital stays, and were more likely to be discharged to intermediate- or long-term care facilities than patients without TAMI. These adverse outcomes are not unique to aortic surgery. Postoperative delirium among patients undergoing major non-heart-related surgery and orthopedic surgery has been noted to lead to a greater likelihood of postoperative complications, an increased hospital stay, and more frequent discharge to rehabilitation or long-term care facilities.[10,12,16]

Delirium may also lead to a loss of physical function for months after hospital discharge. In a prospective cohort study examining patients undergoing surgery for hip fracture, delirium was significantly associated with a decline in activities of daily living, a decrease in ambulation, death, and new nursing home placement 1 month after surgery.[22] In another prospective study of elderly patients on medical and surgical services, delirium was found to be the sole multivariable predictor of loss of activities of daily living at 3 months after discharge.[23] This functional decline persisted at 6 months. In our study, 10 patients (5% of the entire group and 19% of those with development of TAMI) had persistent TAMI at the time of discharge. All of these patients had prolonged recovery at rehabilitation facilities or at home with daily, skilled nursing care. Through review of office charts, interviews with the surgical attending physicians, and phone calls to patients, it was ascertained that all of these patients eventually recovered preoperative levels of orientation. Thus postoperative delirium is a significant morbidity that requires increased hospital resources. Although our patients eventually recovered, other evidence suggests that in many patients with this complication, there may be far-reaching effects, with functional decline evident long after hospital discharge.

Age >65 years, ASA classification >3, diabetes mellitus, previous myocardial infarction, and hypertension were identified as independent preoperative predictors of TAMI. The strongest predictor was advanced age, and this factor has been found in almost all other studies of postoperative confusion and delirium.[4,5,8,14-16,24] Structural brain disease, reduced capacity for homeostasis, vision and hearing impairments, a high prevalence of chronic disease, reduced resistance to acute disease, age-related changes in pharmacokinetics, sleep-wake disturbances, concurrent psychosocial stressors, and decreased cerebrovasomotor reactivity are commonly cited as causes of postoperative confusion, disorientation, or delirium in the elderly.[25]

ASA class has not displayed similar predictive power in other studies. In prospective studies of patients undergoing unilateral or bilateral total knee replacement or a wide variety of major elective, non-heart-related surgical procedures, ASA class was not shown to correlate with or to predict the occurrence of delirium.[13,16] An explanation for this discrepancy may be the greater physiological stress of aortic surgery, as well as the larger numbers of patients in our study with advanced ASA classes (95% of all patients were in ASA class 3 or 4). In addition, more serious comorbid conditions associated with advanced ASA classes may make these patients more vulnerable to physiological derangements that lead to delirium.

Diabetes mellitus, hypertension, and previous myocardial infarction are prevalent in this population and would appear to be nonspecific risk factors. Others have documented that the use of antihypertensive medications was predictive of postoperative delirium.[4,10] Although the pathophysiological linkage between these diseases and postoperative delirium is speculative, it may be that small and medium blood vessel disease predisposes to cerebral hypoperfusion. Günyadin et al[26] documented that postoperative regional cerebral hypoperfusion as demonstrated with single photon emission computed tomography is highly associated with postoperative delirium. In another study there was a significant correlation found between postoperative temporary confusional states and preoperative reduction in vasomotor reactivity as assessed by transcranial Doppler ultrasound scanning of increases in blood flow velocity in response to inhaling carbon dioxide.[27]

It is of interest that none of the intraoperative factors, including aortic cross-clamp level, type of aortic procedure, operative duration, blood loss, or fluid volume infused, predicted the occurrence of TAMI. We also found it surprising that sensory impairments, psychiatric illness, and heavy alcohol use did not achieve significance as predictors. Other prospective studies have shown alcohol to be an independent predictor of postoperative delirium.[14,16] The discrepant findings in our study may be due to the limited number of patients with a history of heavy alcohol intake, as well as aggressive prophylaxis for withdrawal when a history of significant alcohol use was present. In addition, the retrospective nature of our study may have limited the detail and tenacity with which a social history could be elicited in regard to alcohol consumption. More specifically, there may have been a greater number of patients in the heavy alcohol use group than was found by a review of patient charts. The use of psychiatric and anticholinergic medications, although a univariate predictor in our study, did not achieve significance on multivariable analysis. In contrast, other studies have demonstrated that the regular use of these substances is strongly associated with delirium and confusion.[10,12,28-30] All patients in our study with preoperative, mild dementia had development of worsening symptoms and required extra nursing care. This is not surprising and confirms the findings of others.[15,16,22,31,32] There is also compelling evidence in the literature, particularly in that of heart surgery, that prior stroke is an independent predictor of postoperative delirium.[6] Although prior stroke failed to achieve significance as an independent predictor in our study, this may be due to limited numbers of patients with this condition.

PCA and epidural analgesia both showed a significant negative association with the development of TAMI in our study. Another study documented that higher pain scores were associated with an increased risk of delirium over the first 3 postoperative days.[33] Although the use of PCA or epidural analgesia was based on physician/patient preference and not randomized, these findings reinforce the importance of effective pain control. Postoperative factors significantly associated with the development of TAMI included hypoxia, need for reintubation, need for blood transfusion, pneumonia, congestive heart failure, and kidney failure. In addition, a postoperative hematocrit <30% approached significance in this study and was found to be significantly associated with an increased risk of delirium in another study.[34] Given the retrospective nature of our study and the difficulty in documenting timing of complications with respect to the onset of TAMI, we cannot determine a cause and effect relationship between TAMI and other complications. Nevertheless, our impression is that TAMI often precedes these complications and appears to play a causative role.

We have documented that TAMI is a frequent problem in patients undergoing aortic reconstruction. TAMI is associated with increased ventilator use, days spent in the ICU, total hospital stay, and need for posthospitalization care. Because TAMI is highly associated with other morbidities and leads to increased resource use, it should be considered a significant complication of aortic surgery. The main weakness of this study is its retrospective nature and our inability to precisely define delirium according to DSM-IV criteria. We believe that the retrospective analysis of TAMI is an appropriate surrogate for delirium. If anything, in comparison to prospective assessment on a daily basis with sensitive testing interviews, retrospective assessment of TAMI would most likely underestimate the true incidence of delirium in this population. Thus postoperative delirium is probably an even larger problem than implicated by our study. By the same token, patients with very mild, nondisruptive, fleeting episodes were not likely to be included unless the periods of confusion or disorientation coincided with scheduled nursing assessments or during physician visits on 2 or more days. It is likely therefore that our inclusion criteria minimized the accrual of patients with the most mild degree of confusion or disorientation. Future studies should be directed at incorporating pre-preoperative and postoperative psychiatric testing in patients undergoing aortic surgery. It would be of further interest to delineate the pathophysiology of vasomotor reactivity and cerebral hypoperfusion as contributors to postoperative delirium. Confirmation of specific risk factors would allow identification of vulnerable patients and possible therapies designed to prevent this complication.

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Table I. Univariate analysis of preoperative and intraoperative variables examined for association with TAMI

TAMI

Variable	No n=135 n(%)	Yes n=53 n(%)	P value
Men	96(71.1)	37(69.8)	.87
Women	39(28.9)	16(30.2)	-
Age ≥ 65 yrs.	76(56.3)	48(90.6)	<.001
Non-English speaking	3(2.2)	2(3.8)	.55
Nursing home origin	0	0	-
Working	37(27.4)	4(7.5)	.006
Hearing impaired	13(9.6)	7(13.2)	.53
Legally blind	4(3)	2(3.8)	.65
Smoking actively	74(54.8)	26(49.1)	.74
EtOH user	55(40.7)	15(28.3)	.18
Heavy EtOH user	6(4.4)	2(3.8)	.8
Illicit drug user	1(0.7)	2(3.8)	.27
Psychiatric illness	8(5.9)	3(5.7)	.94
Dementia	0	6(11.3)	<.001
Stroke	10(7.4)	9(17)	.05
Residual deficit	2(1.5)	5(9.4)	.11
Aphasia	0	1(1.9)	.11
TIA	6(4.4)	0	.12
Hypertension	75(55.6)	40(75.4)	.02
Diabetes mellitus	11(8.1)	13(24.5)	.006
Coronary artery disease	57(42.2)	34(64.2)	.01
Myocardial infarction	30(22.2)	24(45.3)	.003
Arrhythmia	12(8.9)	10(18.9)	.06
Congestive heart failure	11(8.1)	3(5.7)	.56
COPD	26(19.3)	17(32.1)	.06
Chronic renal insufficiency	14(10.4)	11(20.8)	.06
Dialysis-dependent	3(2.2)	1(1.9)	.89
Hepatic insufficiency	0	0	-
Hypothyroid	8(5.9)	3(5.7)	.94
Hyperthyroid	1(0.7)	0	.53
Psychiatric / anticholinergic medications	34(25.2)	24(45.3)	.01
ASA > 3	40(29.6)	34(64.2)	<.001
Hematocrit < 35%	25(18.5)	14(26.4)	.13
Transfusion required preop.	4(3)	1(1.9)	.26
Infection within 2 weeks preop.	21(15.6)	4(7.5)	.27
Abnormal urinalysis	15(11.1)	4(7.5)	.27
WBC ≥ 12	13(9.6)	4(7.5)	.26
WBC < 5	6(4.4)	6(11.3)	.06
Malnourished	8(5.9)	6(11.3)	.004
Serum sodium ≥150 or<130meq/dl	1(0.7)	0	.67
Serum potassium ≥ 6 or < 3meq/dl	1(0.7)	0	.67
Serum glucose ≥ 300 or < 60mg/dl	3(2.2)	1(1.9)	.81
Mean serum creatinine	1.3 ± 1.0 mg/dl	1.3 ± 0.9 mg/dl	.75

Primary operative indication			.85
Aneurysm	89	33	
Occlusive disease	32	13	
Infected graft / artery	14	7	
Aortic cross clamp location			.45
Infrarenal	99(73.3)	38(71.7)	
Suprarenal	11(8.1)	8(15.1)	
Supramesenteric	2(1.5)	1(1.9)	
Supraceliac	23(17)	6(11.3)	
Combined procedure	11(8.1)	8(15.1)	.15
Duration of surgery	288 ± 160 min.	304 ± 147 min	.52
Intraoperative $Sa0_2 < 90\%$	1(0.7)	1(1.9)	.49
Intraoperative hypotension	40(29.6)	18(34)	.56
Intraoperative hypothermia	32(23.7)	14(26.4)	.77
Estimated blood loss	1610 ± 1869 ml	1723 ± 1629 ml	.7
Fluids / blood products			
Crystaloid	3773 ± 2654 ml	3680 ± 2126 ml	.82
Colloid	1121 ± 737 ml	1320 ± 803 ml	.11
Crystaloid + Colloid	4895 ± 2877 ml	5000 ± 2661 ml	.82
PRBC	3.24 ± 4 units	3.72 ± 4 units	.49
Fresh frozen plasma	0.8 ± 2.4 units	1.3 ± 2.6 units	.24
Platelets	0.8 ± 3.6 units	1.3 ± 4.0 units	.41
Cryoprecipitate	0.2 ± 1.5 units	0.4 ± 0.7 units	.68
Cell saver reinfused	259 ± 397 ml	249 ± 382 ml	.87

EtOH, Ethanol; TIA, transient ischemic attack; COPD, chronic obstructive pulmonary disease; ASA, American Society of Anesthesiology; WBC, White blood cell count; PRBC, Packed red blood cells

Table II. Univariate analysis of postoperative variables examined for association with TAMI

TAMI

Variable	No n=135 n(%)	Yes n=53 n(%)	P value
Fever	18(13.3)	6(11.3)	.71
Hypoxia	92(68.1)	50(94.3)	<.001
Pressors / Inotropes	14(10.4)	6(11.3)	.85
Mean initial days intubated	.59 ± .9 days	1.3 ± 2 days	.002
Need for reintubation	3(2.2)	11(20.8)	<.001
Mean total days intubated	0.6 ± 1.2 days	3.7 ± 7.8 days	<.001
Mean total ICU stay	3.9 ± 2	8.9 ± 9	<.001
ICU readmission	4(3)	6(11.3)	.053
PCA use (I.V. or epidural)	122(90.3)	41(77.4)	.03
Epidural analgesia	63(46.7)	15(28.3)	.03
Hematocrit < 30%	100(74.1)	46(86.8)	.06
Blood transfusion received	74(54.8)	42(79.2)	.008
Mean # units PRBC transfused	1.2 ± 1.4 units	2.6 ± 2.6 units	<.001
Serum sodium <130 or ≥150meq/dl	9(6.7)	1(1.9)	.19
Serum potassium <3.0 or ≥ 6meq/dl	5(3.7)	2(3.8)	.98
Serum glucose < 60 or ≥ 300mg/dl	4(3)	5(9.4)	.38
Mean creatinine increase	.32 ± .83 mg/dl	.67 ± 1.3 mg/dl	.031
Mean days until diet	5.1 ± 2	6.4 ± 2.6	<.001
Reoperation	5(3.7)	4(7.5)	.27
Complications			
Myocardial infarction	4(3)	4(7.5)	.16
Congestive heart failure	1(0.7)	6(11.3)	.003
Cardiac arrhythmia	14(10.4)	10(18.9)	.12
Extremity thrombosis / embolism	3(2.2)	1(1.9)	.89
Stroke	0	0	-
Renal failure	14(10.4)	12(22.6)	.05
Bowel ischemia	1(0.7)	0	.53
Pneumonia	5(3.7)	14(26.4)	<.001
Pulmonary embolus	0	2(3.8)	.14
Wound infection	10(7.4)	3(5.7)	.67
Urinary tract infection	4(3)	2(3.8)	.78
Died	1(0.7)	0	.53
Discharge to nursing / rehab. unit	11(8.1)	20(37.7)	<.001
Postoperative length of stay	9.2 ± 5 days	14.8 ± 11 days	<.001

Table III. Relative risks of developing TAMI or selected postoperative variables

Postoperative Variable	Relative Risk of Developing TAMI Given Presence of Postoperative Variable	Relative Risk of Developing Postoperative Variable Given Presence of TAMI
Oxygen saturation < 92%	5.4	1.4
Patient controlled analgesia	.52	*
Epidural analgesia	.56	*
Need for reintubation	3.3	9.3
ICU readmission	2.3	3.8
Blood transfusion received	2.4	1.4
Congestive heart failure	3.3	15.3
Renal failure	1.8	2.2
Pneumonia	3.2	7.1

- TAMI unable to cause of the postoperative variable.