

Delirium after open heart surgery

Açık kalp cerrahisi sonrası deliryum

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ABSTRACT

Background: This study aims to determine the incidence of delirium and possible risk factors in patients undergoing open heart surgery.

Methods: Between April 2011 and November 2011, preoperative, intraoperative, and postoperative data of 400 patients (276 males, 124 females; mean age 59.7 years; range 19 to 91 years) who underwent open heart surgery were recorded. The Confusion Assessment Method for the Intensive Care Unit (CAM-ICU) was applied to the patients at 24 and 72 hours following surgery. The patients who were consulted by ICU physicians with a preliminary diagnosis of delirium were compared to the patients whose CAM-ICU results were positive.

Results: The incidences of delirium were 3.8% and 1.8% at 24 and 72 hours, respectively. There was a statistically significant difference between the clinical observations of the patients who were reported to have delirium and those who were diagnosed with delirium after the application of the CAM-ICU ($p<0.001$). We found that the clinicians insufficiently recognized hypoactive delirium at 24 and 72 hours following surgery ($p<0.001$). Age, the use of hearing aids and the presence of coronary artery disease during the preoperative stage, intraoperative and postoperative hematocrit levels, postoperative drainage volume, a re-do surgery, history of being bedridden and blood transfusions were predictive risk factors for delirium, as assessed at 24 hours ($p<0.05$). The risk factors at the 72 hours were preoperative age, intraoperative hematocrit level, and postoperative blood transfusion and the duration of mechanical ventilation in the preoperative, intraoperative and postoperative periods ($p<0.05$).

Conclusion: After open heart surgery, using an easy-to-apply scale, such as the CAM-ICU, may be useful for the early diagnosis and treatment of delirium.

Keywords: Cardiovascular surgical procedures; confusion; delirium; intensive care unit.

ÖZ

Amaç: Bu çalışmada açık kalp cerrahisi yapılan hastalarda deliryum insidansı ve muhtemel risk faktörleri belirlendi.

Çalışma planı: Nisan 2011 - Kasım 2011 tarihleri arasında, açık kalp cerrahisi uygulanan 400 hastanın (276 erkek, 124 kadın; ort. yaş 59.7 yıl; dağılım 19-91 yıl) ameliyat öncesi, ameliyat sırası ve ameliyat sonrası verileri kaydedildi. Ameliyat sonrası 24. ve 72. saatlerde hastalara Yoğun Bakım Ünitesi-Konfüzyon Değerlendirme Ölçeği (YBÜ-KDÖ) uygulandı. Yoğun bakım hekimleri tarafından deliryum öntanısıyla konsülte edilen hastalar ile YBÜ-KDÖ sonucu pozitif olan hastalar karşılaştırıldı.

Bulgular: Deliryum insidansı 24. ve 72. saatlerde sırasıyla %3.8 ve %1.8 idi. Deliryum olduğu bildirilen hastalar ile YBÜ-KDÖ uygulanarak deliryum tanısı konulan hastaların klinik gözlemleri arasında istatistiksel olarak anlamlı fark bulundu ($p<0.001$). Klinisyenlerin ameliyat sonrası 24. ve 72. saatlerde hipoaktif deliryumu tanımada yetersiz oldukları saptandı ($p<0.001$). Yirmi dördüncü saatte değerlendirildiği üzere, ameliyat öncesi dönemde yaş, işitme cihazı kullanımı, koroner arter hastalığı varlığı, ameliyat sırası ve ameliyat sonrası dönemde hematokrit düzeyi, drenaj miktarı, tekrar cerrahi, yatağa bağlanma öyküsü ve kan transfüzyonu deliryum açısından öngördürücü risk faktörleri idi ($p<0.05$). Yetmiş ikinci saatteki risk faktörleri ise ameliyat öncesi yaş, ameliyat sırası hematokrit düzeyi ve ameliyat sonrası kan transfüzyonu ve ameliyat öncesi, ameliyat sırası ve ameliyat sonrası dönemdeki mekanik ventilasyon süresi idi ($p<0.05$).

Sonuç: Açık kalp cerrahisi sonrası YBÜ-KDÖ gibi kolay uygulanabilir bir ölçeğin kullanılması, deliryumun erken tanı ve tedavisinde yararlı olabilir.

Anahtar sözcükler: Kardiyovasküler cerrahi işlemler; konfüzyon; deliryum; yoğun bakım ünitesi.



Available online at
www.tgkdc.dergisi.org
doi: 10.5606/tgkdc.dergisi.2015.10797
QR (Quick Response) Code

Received: January 14, 2015 Accepted: April 20, 2015

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Delirium is a clinical condition which can cause serious side effects in patients in intensive care units (ICUs) and develops acutely (within hours or days) and reversibly.^[1] Delirium may be associated with mood alterations, attention deficit, disorganized thoughts, confusion, and an altered state of consciousness.^[2] There are three different types of delirium: hypoactive, hyperactive, and mixed.^[2] In the hyperactive type, hallucinations, delusions, and agitation are prominent, whereas the hypoactive type primarily presents with confusion and sedation. The mixed type, also, includes symptoms of both the hypoactive and hyperactive types. Pure hyperactive delirium is rare (<5%), while the hypoactive and mixed types are prevalent (45% in each). Delirium often develops in the second or third day of hospitalization during the ICU stay and usually lasts for three or four days; although it has been reported to have lasted for up to 60 days.^[3]

Delirium can be seen in nearly all hospitalized patients; however, the highest incidences occur postoperatively in older patients undergoing cardiac surgical interventions due to hypoperfusion and microembolisms,^[1] orthopedic interventions, particularly for femur fractures,^[4,5] and cataract surgery due to vision loss or anti-cholinergic drug use.^[6] Identification of patients at risk and predisposing factors as well as an accurate evaluation of cognitive functions play an important role for the prevention of delirium prior to major surgical interventions, in particular.^[3]

Patients undergoing major surgeries such as cardiac surgeries are at an increased risk due to the complexity of surgical procedures, the use of both intraoperative and postoperative anesthetics and other pharmacologic agents, and possible postoperative complications. Once delirium develops, it cannot be solely attributed to surgery; rather, several factors, such as infection and existing secondary medical conditions, should be considered.^[3-7]

The gold standard in the diagnosis of delirium is the evaluation of the patient by a psychiatrist according to the Diagnostic and Statistical Manual of Mental Disorders fourth edition (DSM)-IV criteria combined with the clinical history and examination findings. However, the diagnosis of delirium may be more challenging in patients staying in the ICU. The Confusion Assessment Method for the Intensive Care Unit (CAM-ICU) was developed for ICU physicians to diagnose delirium in patients on mechanical ventilation.

To date, several studies which were performed to examine possible risk factors for the development

of delirium were in a retrospective design using demographic data and delirium scales from the patient files.^[8] Our study, on the other hand, had a prospective design for the detection the incidence and possible risk factors for delirium. More importantly, we also aimed to measure how successful clinicians are in identifying patients with this condition.

PATIENTS AND METHODS

This prospective observational study was performed on patients from the Cardiovascular Surgery ICU in a tertiary care hospital. The study protocol was approved by the institutional ethics committee. Between April 2011 and November 2011, 423 patients underwent open heart surgery. As eight of them died in the perioperative period, three did not give an informed consent form, and 12 foreign patients were unable to communicate well, a total of 400 patients (276 males, 124 females; mean age 59.7 years; range 19 to 91 years) were included. Preoperative, intraoperative, and postoperative risk factors were recorded (Table 1).

The CAM-ICU is considered to be the best delirium scale among the scales available in English, and its sensitivity, specificity, and confidence have been reported to be 73 to 100%, 98 to 100%, and Kappa=0.64-0.96, respectively.^[9] The Turkish version of the CAM-ICU has been also validated. Its sensitivity (65 to 69%) can be improved, while the specificity and confidence have been reported to be 97% and Kappa=0.96, respectively.^[10]

In the diagnosis of delirium, the CAM-ICU was applied by a single person to all patients at 24 and 72 hours following surgery. The patients with a preliminary diagnosis of delirium from the ICU physicians or nurses were also recorded. The results of the CAM-ICU were compared between the patients with and without a preliminary diagnosis of delirium. Delirium was diagnosed according to the CAM-ICU as follows:

The presence of one or both of these features (1 and/or 2):

1. Acute initial delirium or fluctuating progression, and
2. Recklessness or the presence of either of these features (3 and/or 4):
3. Disorganized thoughts
4. Impaired level of consciousness

The patients were separated into two groups: patients with no delirium and patients with delirium at 24 and 72 hours. The variables were evaluated at 24 and 72 hours between these groups.

Table 1. Possible risk factors

Preoperative	Intraoperative	Postoperative
<ul style="list-style-type: none"> • Age • Sex • Marital status (single, married, divorced) • Education status (primary school/secondary school/college) • Occupation • Income level • Body mass index • Use of hearing aids/ glasses • Tobacco use • Alcohol use • History of psychiatric disease • Dementia • History of systemic disease • Medication use • History of substance addiction • History of anti-hyperlipidemic drug use • Serum albumin level 	<ul style="list-style-type: none"> • Type of surgery (urgent/elective) • Duration of anesthesia • Duration of surgery • Induction agents (fentanyl, midazolam, etomidate/rocuronium) • Duration of CPB • Duration of cross-clamp • Duration of selective cerebral perfusion • Level of hypothermia • CPB flow-rate • Presence of blood transfusion • Drugs (thiopental/propofol) • Artery blood gas follow-up • Hematocrit level 	<ul style="list-style-type: none"> • Blood pressure, heart rate, and oxygen saturation on admission to ICU • Heart rhythm • 24 hour drainage amount • 24 hour urine level • Presence of blood transfusion • Hematocrit level (>30%) • Desaturation (>90%) • Serum sodium (Na) level • Serum albumin level • BUN/creatinine rate • Presence of SIRS • Development of renal/neurological/respiratory/gastrointestinal complications • Occurrence of an unexpected re-do surgery • Surgical complications • Cardiogenic/septic shock • Duration under mechanical ventilation • History of being bedridden • Presence of urinary catheter/rectal tube • Presence of feeding with TPN/nasogastric catheter

CPB: Cardiopulmonary bypass; ICU: Intensive care unit; BUN: Blood urea nitrogen; SIRS: Systemic inflammatory respiratory syndrome; TPN: Total parenteral nutrition.

Statistical analysis

Statistical analysis was performed using PASW version 18.0 (SPSS Inc., Chicago, IL, USA) software program. The risk factors were analyzed with a logistic regression test. A *p* value of <0.05 was considered statistically significant. The chi-square test was used to evaluate the agreement of the observations of the clinicians and the diagnoses according to the CAM-ICU. A *p* value of <0.001 was considered statistically significant.

RESULTS

Delirium developed in 15 (3.8%) and seven (1.8%) patients at the postoperative 24th and 72nd hours, respectively, according to the results of the CAM-ICU. Delirium did not develop at 72 hours among the patients who developed delirium at 24 hours. The patients with delirium were also classified as hypoactive or hyperactive. At 24 hours, 12 patients (3%)

were hypoactive, and three (0.8%) were hyperactive, whereas at 72 hours, the number of patients who were hypo- and hyperactive was three (0.8%) and four (1%), respectively (Table 2). However, the mixed type was not evaluated, as the patients were evaluated at a single time point and was unable to be continuously observed.

The clinicians properly evaluated nine patients (60%) at 24 and four patients (57.14%) at 72 hours. A total of 50% (n=6) and 100% (n=3) patients who were hypoactive at the 24 and 72 hours were consulted to the psychiatry clinic, respectively. At 72 hours, the clinicians did not detect any of the patients with hypoactive delirium and referred all patients (n=4) with hyperactive delirium to a psychiatrist.

The numbers of patients with delirium based on the observations of clinicians were similar to those who were detected based on the CAM-ICU (*p*<0.001). The delirium types in these two groups were also compared and a correlation was found (*p*<0.001).

Table 2. Percentages of delirium at 24 and 72 hours following surgery and distributions of delirium types

	Hypoactive type		Hyperactive type		Total
	n	%	n	%	%
Delirium at 24 hours (n=15)	12	3	3	0.8	3.8
Delirium at 72 hours (n=7)	3	0.8	4	1	1.8

The statistically significant risk factors among the patients who developed delirium at 24 hours were age, the use of hearing aids, coronary artery disease, intraoperative hematocrit (Hct) levels, postoperative Hct levels, unexpected re-do surgery, history of being bedridden, postoperative 24-hour drainage volume, and postoperative blood transfusion ($p < 0.05$; Table 3).

The statistically significant risk factors for the patients who developed delirium at 72 hours were age, intraoperative Hct level, postoperative blood transfusion, and the duration of mechanical ventilation ($p < 0.05$; Table 4).

DISCUSSION

In the present study, the incidence of delirium detected in the first postoperative 72 hours was 5.6%. Among these patients, 3.8% developed delirium at 24 hours, and 1.8% developed delirium at 72 hours. On the other hand, there are major differences in the results of studies which examined the incidences of delirium in patients who underwent cardiovascular surgery. The incidence of delirium ranges widely from 8.4 to 70% across studies.^[3-11] In the present study, the incidence of delirium was considerably lower (5.6%) in the first 72 hours after open heart surgery. The wide range of age of the patients, the characteristics of the patients and the ICUs, differences in the sample sizes,

and durations of data collections, differences in the delirium scales and diagnostic criteria, and whether the administrator of the CAM-ICU was a physician or a nurse might be reasons for the significantly different results of the studies on the incidence of delirium.^[2] In addition, as seen in Table 5, the use of different scales might have produced different results. Ely et al.^[9] and Caza et al.^[21] found higher incidences than our results and we also used the same scale in our study. The reason for this discrepancy can be attributed to the characteristics of the study populations. The mean age in the Ely et al. study^[9] was 66 years, whereas it was 59.7 years in our study. It has been shown that the incidence of delirium increases with age.^[11] In addition to the use of different study designs and methods, different diagnostic scales, and the fact that most of the previous studies were retrospective, the year of publications might be also one of the reasons for this discrepancy, as more recent studies reported lower incidences.^[8]

Despite the prevalence and adverse clinical effects of delirium, it is often overlooked by health care providers. Several studies have shown that 32 to 84% of patients are left undiagnosed.^[12] Due to the acute initiation of delirium, its fluctuating course, and its clinical similarities to depression and dementia, delirium may be misdiagnosed or not diagnosed at all.^[3]

Table 3. Statistically significant risk factors and their mean values among the patients who developed delirium at 24 hours following surgery

Risk factors	Delirium – (n=385)			Delirium + (n=15)			p	OR	95% CI
	n	%	Mean±SD	n	%	Mean±SD			
Age (years)			58.9±11.8			73.8±6.8	0.01	32.46	4.22-249.78
Use of hearing aids	18	4.8		2	13.3		0.04	2.04	1.03-4.03
Presence of CAD	134	34.8		11	73.3		0.006	5.15	1.61-16.48
Intraoperative Hct level (%)			24.1±3.4			18.6±2.5	<0.001	0.54	0.49-0.68
Postoperative Hct level (%)			29.8±4.0			25.8±2.5	<0.001	0.74	0.63-0.87
Unexpected re-do surgery	23	6		5	33.3		<0.001	7.87	2.48-24.93
History of being bedridden	36	9.4		5	33.3		0.006	4.84	1.57-14.96
Postoperative 24-hour drainage volume (mL)			871.2 ±526.7			1343.3±455.1	0.002	27.34	3.58-208.43
Postoperative blood transfusion	134	37.4		13	86.7		0.008	1.01	1.00-1.02

SD: Standard deviation; CI: Confidence interval; CAD: Coronary artery disease; Hct: Hematocrit.

Table 4. Statistically significant risk factors and their mean values among the patients who developed delirium at 72 hours following surgery

Risk factors	Delirium – (n=393)	Delirium + (n=7)	p	OR	95% CI
	Mean±SD	Mean±SD			
Age (years)	59.1±11.9	74.9±6.6	0.018	13.01	1.55-109.21
Intraoperative Hct level (%)	24.0±3.5	18.1±2.6	<0.001	0.56	0.41-0.76
Postoperative Hct level (%)	29.7±4.0	27.7±3.5	0.037	0.87	0.72-1.07
Duration of mechanical ventilation (hour)	19.2±56.2	147.0±178.0	0.013	1.01	1.01-1.02

SD: Standard deviation; CI: Confidence interval; Hct: Hematocrit.

Since studies have shown that postoperative delirium primarily develops within the first three days,^[3] we evaluated the development of delirium at postoperative 24th and 72nd hours. We found that the clinicians were unable to recognize delirium in 40.9% of the patients within the first 72 hours. Furthermore, although the clinicians were successful in recognizing hyperactive cases (100%), they were inadequate in identifying hypoactive cases (60%). Although hypoactive delirium is more frequent and more harmful for patients in the long-term, clinicians may underrate hypoactivity and miss the appropriate diagnosis, which increases the risks of aspiration and re-intubation.^[10] A scale may be regularly used by clinicians to recognize delirium in the acute period and provide appropriate treatment in cardiovascular ICUs.^[8,13]

In the present study, history of coronary artery disease (CAD) and age were found to be important risk factors. The postoperative development of cognitive impairment is explained by three main mechanisms: intraoperative cerebral micro-embolism and ischemic injury, hypoperfusion, and systemic inflammatory response.^[14] According to these authors' hypothesis, chronic hypoperfusion of the brain, reduced cerebral reserve and perioperative hemodynamic fluctuations may result in decreased tolerance or micro-embolisms. In older populations, the predisposition

to delirium is associated with reduced cerebral neuronal density, blood flow, metabolism, and levels of neurotransmitters.^[14] Atherosclerosis and delirium share common risk factors, such as older age, male sex, hypertension and peripheral artery disease.^[14] Review of the literature have shown that atherosclerosis is associated with an increased risk of delirium in patients with coronary artery bypass graft (CABG) surgery.^[15]

In the present study, intraoperative Hct levels, postoperative Hct levels, undergoing re-do surgery, total drainage, and postoperative blood transfusions are of utmost importance; however, there was no correlation between the type of surgery and delirium. The following four of the intraoperative risk factors reported in the literature were observed more frequently in the patients with delirium than those without: aortic reconstruction surgery, low body temperature, a long duration of circulatory arrest, and blood transfusion of more than one liter.^[3] These findings revealed that delirium exhibited a trend toward developing more frequently with complex surgical procedures, such as aortic reconstruction, than with congenital defect surgeries in younger patients with less comorbidities. Complex procedures are not only more likely in the older population, but also involve longer operation durations and higher volume of blood transfusions. Together, these data suggest that the providing of

Table 5. Incidences of delirium reported in different studies

References	Incidence (%)	Scale	Scaling time (hour)	Mean age (year)
Chang et al. ^[3]	41.7	DSM-4	48-72	56.6
Rudolph et al. ^[11]	29.0	MSI and CAM	48	59.5
Kazmierski et al. ^[8]	8.0	CAM-ICU	Retrospective	64.8
Rudolph et al. ^[22]	21.4	MSI and CAM	24-48-72	70.5
Rudolph et al. ^[23]	52.0	MSI	48	73.7
Boogaard et al. ^[24]	19.0	CAM-ICU	24	66.0

DSM: The diagnostic and statistical manual of mental disorders fourth edition; MSI: Mental status interview, CAM: Confusion assessment method; ICU: Intensive care unit.

adequate cerebral blood flow and monitoring should be emphasized to avoid hemodynamic fluctuations and micro-embolism during surgery.^[3]

In the present study, the intraoperative and postoperative Hct levels were significantly different among the patients who developed delirium at 24 and 72 hours following surgery. Among the patients who developed delirium at 24 hours, postoperative blood transfusion, history of unexpected re-do surgery, and drainage amount were found to be critical. All of these factors may cause a tendency for the development of delirium through the impairment of cerebral perfusion and the synergistic effects of hemodynamic instability, fluctuating cerebral blood flow, and reduced cerebral oxygen levels. The critical blood transfusion volume which is postoperatively predictive of the development of delirium has been reported in several studies to be more than two liters;^[7] however, Chang et al.^[3] reported this volume as more than one liter. This discrepancy can be explained by the lower body surface areas of Chinese patients compared to patients from the Western countries. The reports showed that, in patients with postoperative delirium, low Hct levels (<30%) were more frequent, which was associated with organ dysfunction due to insufficient oxygen.^[16] On the other hand, it is not clear whether there is a relationship between the etiology of postoperative delirium and neurocognitive impairment following cardiopulmonary bypass (CPB), although both conditions indicate cerebral dysfunction.^[17]

We found no correlations between the development of delirium and valvular surgery or CABG. However, a theory has been developed indicating that embolic burdens involving specific materials and air in the brain of patients undergoing intracardiac (valvular) surgery are higher among patients undergoing CABG surgery; therefore, these patients are at an increased risk for the development of delirium, which causes them to be more vulnerable to postoperative neuropsychiatric impairments.^[18] We found no correlations between the development of delirium at the postoperative 24th and 72nd hours and planned surgery type, duration of CPB, duration of cross-clamp, or duration of surgery and anesthesia. Van Dijk et al.^[19] found similar cognitive results in patients who underwent CABG surgeries with (on-pump) or without (off-pump) CPB and concluded that factors other than CPB could be responsible for cognitive changes. In another study, factors other than CPB leading to an altered mental status in cardiac surgery patients were reported, and postoperative sedation was found to be the most critical factor.^[18]

Another study found no relation between the duration of CPB and cognitive impairment.^[20] However, the authors assumed that the duration of surgery was a dependent variable in terms of cognitive impairment and it might have been associated with increased exposure of anesthetic agents or increased embolic burden during surgery.^[21] In the present study, we did not find any correlation between delirium and the procedures with CPB, which is in accordance with the findings of another study.^[19]

Furthermore, we found that unexpected re-do surgery was critical among the patients with delirium at 24 hours following surgery and this finding is similar to those of other studies.^[7] The high prevalence of unexpected re-do surgery among patients who developed delirium following cardiac surgery might have been caused by massive bleeding or cardiac tamponade after cardiomy. As a result, it might worsen the circulatory condition and lead to delirium via obstruction of the cerebral circulation.^[3]

However, our study also has some limitations. Firstly, the patients were unable to be monitored repeatedly across the entire day and the ICU physicians referred the patients with a preliminary diagnosis of delirium except at the times at which they applied the CAM-ICU. Therefore, it limited our ability to recognize delirium with fluctuations. Secondly, we were unable to observe the patients after 72 hours following surgery and unable to evaluate them after they left the ICU. Therefore, our sample size was small.

In conclusion, the incidence of delirium detected in the first postoperative 72nd hours in our study was 5.6% and the clinicians insufficiently recognized delirium. Additionally, this study showed that intraoperative and postoperative Hct levels and unexpected redo surgery are the major risk factors for development of delirium.

We believe that the addition of an easy-to-apply and valid scale, such as the CAM-ICU, to the patients may be useful for the early detection of delirium to closely monitor the patients in ICU.

Declaration of conflicting interests

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support for the research and/or authorship of this article.

REFERENCES

1. Sezer Ö, Karlıdağ R, Nisanoğlu V, But K, Özcan C, Ünal S. Risk factors for delirium in patients with in coronary bypass operation. *New Symposium* 2004;42:182-8.
2. Tuğlu C, Yıldırım E. Delirium. A frequent psychiatric syndrome encountered in hospitalized patients. *Balkan Med J* 2002;19:55-64.
3. Chang YL, Tsai YF, Lin PJ, Chen MC, Liu CY. Prevalence and risk factors for postoperative delirium in a cardiovascular intensive care unit. *Am J Crit Care* 2008;17:567-75.
4. Holroyd-Leduc JM, Abelseth GA, Khandwala F, Silvius JL, Hogan DB, Schmaltz HN, et al. A pragmatic study exploring the prevention of delirium among hospitalized older hip fracture patients: Applying evidence to routine clinical practice using clinical decision support. *Implement Sci* 2010;5:81.
5. Yaşayacak A, Eker F. Kalp damar cerrahisi yoğun bakım ünitesinde yatan hastalarda deliryum ve risk faktörlerinin belirlenmesi. *Türk Gogus Kalp Dama* 2012;20:265-74.
6. Parikh SS, Chung F. Postoperative delirium in the elderly. *Anesth Analg* 1995;80:1223-32.
7. Bucarius J, Gummert JF, Borger MA, Walther T, Doll N, Falk V, et al. Predictors of delirium after cardiac surgery delirium: effect of beating-heart (off-pump) surgery. *J Thorac Cardiovasc Surg* 2004;127:57-64.
8. Kazmierski J, Kowman M, Banach M, Fendler W, Okonski P, Banyas A, et al. Clinical utility and use of DSM-IV and ICD-10 Criteria and The Memorial Delirium Assessment Scale in establishing a diagnosis of delirium after cardiac surgery. *Psychosomatics* 2008;49:73-6.
9. Ely EW, Inouye SK, Bernard GR, Gordon S, Francis J, May L, et al. Delirium in mechanically ventilated patients: validity and reliability of the confusion assessment method for the intensive care unit (CAM-ICU). *JAMA* 2001;286:2703-10.
10. Akinci Seda B, Rezaki M, Özdemir H, Çelikkcan A, Kanbak M, Yorgancı K, et al. Validity and reliability of confusion assessment method for the intensive care unit. *Türk J Anaesth Reanim* 2005;33:333-41.
11. Rudolph JL, Ramlawi B, Kuchel GA, McElhaney JE, Xie D, Sellke FW, et al. Chemokines are associated with delirium after cardiac surgery. *J Gerontol A Biol Sci Med Sci* 2008;63:184-9.
12. Maldonado JR, Wyson A, van der Starre PJ, Block T, Miller C, Reitz BA. Dexmedetomidine and the reduction of postoperative delirium after cardiac surgery. *Psychosomatics* 2009;50:206-17.
13. Ayazoğlu T, Tür H, Bolat C, Özkaynak İ, Candan MA. Yaşlılarda kardiyak cerrahi sonrası yoğun bakımda deliryum prevalansı ve risk faktörleri. *J Exp Clin Med* 2012;29:101-7.
14. Svedjeholm R, Håkanson E, Szabó Z, Vánky F. Neurological injury after surgery for ischemic heart disease: risk factors, outcome and role of metabolic interventions. *Eur J Cardiothorac Surg* 2001;19:611-8.
15. Rudolph JL, Babikian VL, Birjiniuk V, Crittenden MD, Treanor PR, Pochay VE, et al. Atherosclerosis is associated with delirium after coronary artery bypass graft surgery. *J Am Geriatr Soc* 2005;53:462-6.
16. Murphy GJ, Angelini GD. Indications for blood transfusion in cardiac surgery. *Ann Thorac Surg* 2006;82:2323-34.
17. Brown T. Basic mechanisms in the pathogenesis of delirium. In: Stoudemire AFB, Greenberg DB, editors. *The Psychiatric Care of the Medical Patient*. 2nd ed. New York: Oxford; 2000. p. 571-80.
18. Dubois MJ, Bergeron N, Dumont M, Dial S, Skrobik Y. Delirium in an intensive care unit: a study of risk factors. *Intensive Care Med* 2001;27:1297-304.
19. Van Dijk D, Jansen EW, Hijman R, Nierich AP, Diephuis JC, Moons KG, et al. Cognitive outcome after off-pump and on-pump coronary artery bypass graft surgery: a randomized trial. *JAMA* 2002;287:1405-12.
20. Atalan N, Sevim M. Postoperative delirium associated with prolonged decline in cognitive function and sleep disturbances after cardiac surgery. *Türk Gogus Kalp Dama* 2013;21:358-63.
21. Caza N, Taha R, Qi Y, Blaise G. The effects of surgery and anesthesia on memory and cognition. *Prog Brain Res* 2008;169:409-22.
22. Rudolph JL, Jones RN, Grande LJ, Milberg WP, King EG, Lipsitz LA, et al. Impaired executive function is associated with delirium after coronary artery bypass graft surgery. *J Am Geriatr Soc* 2006;54:937-41.
23. Rudolph JL, Jones RN, Levkoff SE, Rockett C, Inouye SK, Sellke FW, et al. Derivation and validation of a preoperative prediction rule for delirium after cardiac surgery. *Circulation* 2009;119:229-36.
24. van den Boogaard M, Peters SA, van der Hoeven JG, Dagnelie PC, Leffers P, Pickkers P, et al. The impact of delirium on the prediction of in-hospital mortality in intensive care patients. *Crit Care* 2010;14:146.