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Frequency of delirium after carotid endarterectomy

Karotis endarterektomisini takiben görülen delirium sıklığı

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ABSTRACT

Internal carotid artery stenosis is a consequence of systemic atherosclerotic disease. Internal carotid artery endarterectomy is a treatment method used to prevent life-threatening strokes in patients with severe internal carotid artery stenosis. Delirium may occur in patients after carotid endarterectomy due to hemodynamic changes due to cerebral perfusion deficiency. This study was conducted to determine the frequency and risk factors of delirium in patients who undergoing carotid endarterectomy.

The research was a descriptive and cross-sectional prospective study. Research data were collected in 2 years and 83 patients who agreed to participate in the study were reached. Sociodemographic and clinical characteristics data collection form, intensive care delirium screening checklist, and pain scale were used.

Delirium was detected in 2.07% of the patients after carotid endarterectomy. The mean oxygen saturation values of the patients with and without delirium in the 2-4 hours after carotid endarterectomy were found to be a statistically significant difference ($p<0.05$). After carotid endarterectomy oxygen saturation means of the patients who developed delirium was lower than the other patients in the 2-4 hours postoperatively. In patients who sleep 4 hours or more, delirium was less common than other patients. It was found that the means pain scores of patients who developed and did not develop delirium on the 1st postoperative day were statistically significant ($p<0.05$)

In conclusion, after internal carotid artery endarterectomy, advanced age, low arterial partial oxygen pressure and oxygen saturation, presence of postoperative pain and short sleep duration are risk factors for delirium.

Keywords: Carotid stenosis; delirium; endarterectomy.

ÖZET

İnternal karotis arter stenozu sistemik aterosklerotik hastalığın bir sonucudur. İnternal karotis arter endarterektomisi, ciddi internal karotis arter stenozu olan hastalarda hayatı tehdit eden inmeleri önlemek için kullanılan bir tedavi yöntemidir. Karotis endarterektomi sonrası hastalarda serebral perfüzyon eksikliğine bağlı hemodinamik değişiklikler nedeniyle deliryum görülebilir. Bu çalışma karotis endarterektomi yapılan hastalarda deliryum sıklığını ve risk faktörlerini belirlemek amacıyla yapıldı.

Araştırma tanımlayıcı ve kesitsel prospektif bir çalışmadır. Araştırma verileri 2 yılda toplandı ve çalışmaya katılmayı kabul eden 83 hastaya ulaşıldı. Sosyodemografik ve klinik özellikler veri toplama formu, yoğun bakım deliryum tarama kontrol listesi ve ağrı ölçeği kullanıldı.

Karotis endarterektomi sonrası hastaların %2.07'sinde deliryum saptandı. Karotis endarterektomi sonrası 2-4 saat içinde deliryum gelişen ve gelişmeyen hastaların oksijen satürasyon ortalamaları arasında istatistiksel olarak anlamlı fark bulundu ($p<0.05$). Karotis endarterektomi sonrası deliryum gelişen hastaların ameliyat sonrası 2-4. saatlerdeki oksijen satürasyon ortalamaları diğer hastalara göre daha düşüktü. Dört saat ve daha fazla uyuyan hastalarda deliryum diğer hastalara göre daha azdı. Ameliyat sonrası 1. günde deliryum gelişen ve gelişmeyen hastaların ağrı skoru ortalamaları istatistiksel olarak anlamlı bulundu ($p<0.05$)

İnternal karotis arter endarterektomisi sonrası ileri yaş, düşük arteriyel parsiyel oksijen basıncı ve oksijen saturasyonu, postoperatif ağrı varlığı ve kısa uyku süresi deliryum için risk faktörleridir.

Anahtar kelimeler: Karotis stenozu; deliryum; endarterektomi

INTRODUCTION

Internal carotid artery (ICA) stenosis is more than 50% narrowing of the internal carotid artery, which is symptomatic and asymptomatic (1). ICA stenosis is a consequence of systemic atherosclerotic disease (2). Medical treatment or surgical treatment (ICA endarterectomy or ICA stenting, thrombolysis) is performed in ICA stenosis (1,2).

ICA endarterectomy is a treatment method used to prevent life-threatening strokes in patients with severe ICA stenosis. It has been reported that mild cognitive dysfunction may occur in 27-31% of patients after carotid endarterectomy due to hemodynamic changes due to carotid stenosis and lack of cerebral perfusion related to cerebral embolism, as well as various individual factors (3).

Delirium is one of the most common postoperative complications in different group patients. Defined as a state of acute confusion that is commonly reversible and preventable, delirium is characterized by: fluctuating levels of attention and awareness; disorientation; memory impairment; disturbances of perception; and disorganized thinking. It occurs due to a vulnerability of cerebral functioning to pathophysiological stressors or triggers (4).

It has been reported in the literature that delirium is common in intensive care patients, cardiac and hip surgery patients (5-7). Studies on delirium in patients undergoing carotid endarterectomy are limited (8, 9).

Therefore, this study was conducted to determine the frequency and risk factors of delirium in patients who undergoing carotid endarterectomy in intensive care unit (ICU).

MATERIAL and METHOD

The study was a descriptive and an observational cohort design.

The study was carried out in the cardiovascular surgery intensive care unit (ICU) of a training and research hospital in the province of Izmir in the Aegean Region.

Patients who undergoing surgery for ICA stenosis in a training and research hospital were included in the sample. Data were collected in January 2021-December 2022. A total of 87 patients undergoing carotid endarterectomy in 2 years. A total of 4 patients were excluded from the sample because 2 patients had reoperation and the other 2 patients had cerebrovascular disease after surgery. 83 patients who agreed to participate in the study were reached.

Data were collected using sociodemographic and clinical characteristics form which is prepared by the researchers, Intensive Care Delirium Control Scale, and Numeric Pain Scale.

Sociodemographic and clinical characteristics data collection form is a form consisting of 22 questions describing the sociodemographic (such as age, gender) and clinical (such as Arterial Partial Oxygen Pressure (pO_2), Arterial Partial Carbon Dioxide Pressure (pCO_2), Oxygen Saturation (SpO_2), Hemoglobin (Hb), Hematocrit (Htc), Sodium (Na),and Blood Urea Nitrogen (BUN) laboratory values) characteristics of the patients.

The checklist was developed by Bergeon et al for patients in the ICU in 2001 and was revised in 2014. The reliability and validity study of the "Intensive Care Delirium Screening Checklist" for Türkiye was conducted by Köse et al. in 2016, the sensitivity was 90.6% and the specificity was 82.1%. In the study, it was stated that the checklist is suitable for patients who do not have a verbal, visual, or auditory connection, and it is an easy-to-use tool with high validity and reliability for the detecting of delirium. It has been stated that the checklist is a tool that can be integrated into daily nursing care processes in Turkish patients and can be used routinely in the ICU (10).

The checklist consisted of eight items. Items: change in level of consciousness, inattention, disorientation, hallucination/ delusions/ psychosis, psychomotor agitation or regression, inappropriate speech or mood, awakening from sleep/cycle disruption, symptom fluctuation. A score in the range of 0-8 is taken from the scale. A total score greater than four indicated delirium.

Numerical pain scale

In this one-dimensional scale, which determine the severity of pain, it is aimed to explain the patient's pain in numbers. Numerical scales start with

the absence of pain (0 points) and reach the level of unbearable pain (10 points).

Data collection

The patients in the ICU, who in the extubated after the surgery, were evaluated with the data collection tools by the investigator twice a day (08:00-16:00) and night (16:00 -08:00). We took some values of the patients such as SpO2, blood gas and laboratory from the patient file. The researcher observed the patient's sleep duration at night.

Evaluation of data

Statistical analysis; were performed with the computer program SPSS 22.0 (SPSS Inc. Chicago, Illinois, USA). Data were expressed as means with standard deviation. Statistics of descriptive data were presented as frequency, percentage, and mean ± standard deviation. The distribution of data was tested with Kolmogorov-Smirnov. Non-parametric data were analyzed with the Mann-Whitney U test (significance test of the difference between two means in independent groups). The Pearson chi-square test for categorical variables and Fisher's Exact Test was used. A p value of < .05 was considered significant. Spearman's rho correlation analysis was performed for the variables of age, pO_2 in 2-4 hours postoperatively, SpO_2 in 2-4 hours postoperatively, 1st day postoperatively pain score, and postoperative night sleep duration variables that were significantly different from delirium development status.

Research ethics

Ethical approval (decision number: 888) from İzmir Katip Çelebi University Non-Interventional Research Ethics Committee and institutional permission from İzmir Atatürk Training and Research Hospital were obtained for the research. Patients participating in the study were informed about the study. Oral and written consent was obtained from the patients during the preoperative period.

RESULTS

Our study results that 80.7% of the patients are male. The mean age was 67.46 (min=48-max=87). 53% of the patients had left side and 47% right side carotid endarterectomy. Nobody patient had been surgery bilateral ICA endarterectomy. Bilateral ICA stenosis was detected in 20.48% of the patients. Delirium was defined 2.07% (n=4) of the patients after carotid endarterectomy. One patient with postoperative delirium had bilateral ICA stenosis, whereas 16 patients without postoperative delirium had bilateral ICA stenosis before carotid endarterectomy. It was found that there was no significant difference in terms of delirium in patients with and without bilateral ICA stenosis in patients who undergoing carotid endarterectomy (x^2=0.053; p=0.608). The postoperative stay in the ICU was 1.09±0.45 days in patients with delirium and 1.00±0.00 days in patients without delirium (p= 0.669; p>0.05).

The clinical characteristics of the patients on postoperative 0st and 1st day are given in table 1. Patients' cross-clamp times were 17.57±5.6 minutes. Intubation times during surgery were 0.50 ±1.66 hours. The mean postoperative pain score of the patients was 0.96±1.76 on the 0st postoperative day, and 0.24±0.82 on the 1st postoperative day. The pO_2 values of the patients were 108.44 ± 22.47 mmHg on the 0st postoperative day, and 102.93±22.41 mmHg on the 1st postoperative day. Postoperative pO_2 values were found to be high because the patients received oxygen therapy at 2lt/min with an oxygen mask in ICU (Table 1). The mean Hb value of the patients was 11.75±1.56 g/dL on the 0st postoperative day, and 11.37±1.49 g/dL on the 1st postoperative day. The mean Htc value of the patients was found to be 36.16 % ±4.7 on the 0th postoperative day, and 34.91±4.4 % on the 1st postoperative day.

The mean Na value of the patients was 139.79 ±3.54 mEq/L, and 138.68 ±3.34 mEq/L on the 1st postoperative day. The mean BUN value of the patients was 16.84 ±6.73 mg/dL on the 0th postoperative day, and 17.13 ±7.62 mg/dL on the 1st postoperative day.

A statistically significant difference was found between the mean age of patients with and without delirium who undergoing carotid endarterectomy. Patients who develop delirium have a higher mean age (U=48.5; p=0.02; p<0.05). There was no statistically significant difference between the carotid cross-clamp times of patients with and without delirium (U=156.5; p=0.974; p>0.05) (Table 2). There was a significant and positive weak correlation between delirium and age (r=0.257, p= .019).

There was no statistically significant difference in the means pain scores of patients who developed and did not develop delirium on postoperative day 0 (U=100.50; p=0.115; p>0.05). It was found that the means pain scores of patients who developed and did not develop delirium on the 1st postoperative day were statistically significant (U=85.50; p=0.001; p<0.05) (Table 2). A significant and positive weak correlation was found between delirium and postoperative 1st day pain score (r=0.353, p= .001).

It was found that there was no significant difference between gender and development of delirium in patients who had carotid endarterectomy (x^2=0.088; p=1.00; p>0.05). Additionally, it was found that there was no significant relationship between the right-left surgical side and delirium in patients who had carotid endarterectomy (x^2=3.725; p=0.11). Cervical plexus block anesthesia had been used in 46.98% of the patients and inhale anesthesia had been used in %33.73 of the patients. It was found that there was no significant relationship between the development of delirium according to the anesthesia given to the patients in carotid endarterectomy (x^2 =0.390; p=0.225; p>0.05).

Table 1: Clinical characteristics of the patients (n=83).				
		Mean ±SD	**Min.**	**Max.**
Age		67.46 ±8.3	48	87
Carotid Cross-Clamp Time (minute)		17.57 ±5.6	8.00	35.00
Intubation Time (hours) (during surgery) (n= 17) *		0.50 ±1.66	.00	3.00
Intensive Care Hospitalization Period (days)		1.09 ±0.45	1.00	4.00
PO day 0	Pain Score (between 0-10)	0.96±1.76	0	8
	pO_2 value (mmHg)	108.44±22.47	52	139
	pCO_2 value (mmHg)	36.66 ± 5.91	20.00	53.00
	SpO_2 value (%)	97.38 ±2.02	86.00	100.00
	Hb value (g/dL)	11.75 ±1.56	7.10	15.30
	Htc value (%)	36.16 ±4.7	22.30	46.80
	Na value (mEq/L)	139.79 ±3.54	130.00	148.00
	BUN value (mg/ dL)	16.84 ±6.73	5.00	41.00
PO day 1	Pain Score (between 0-10)	0.24±0.82	0	4
	pO_2 value (mmHg)	102.93 ±22.41	64.00	132.00
	pCO_2 value (mmHg)	37.86 ±3.9	28.30	55.00
	SpO_2 value (%)	97.36 ±1.91	89.00	99.70
	Hb value (g/dL)	11.37 ±1.49	8.30	14.80
	Htc value (%)	34.91 ±4.4	25.90	45.20
	Na value (mEq/L)	138.68 ±3.34	130.00	149.00
	BUN level (mg/dL)	17.13 ±7.62	6.00	56.00
*Only 17 patients were intubated during the surgery. BUN=blood urea nitrogen, Hb=hemoglobin, Htc=Hematocrit, Na=sodium, pCO_2=arterial partial carbon dioxide pressure, PO=postoperative, pO_2=arterial partial oxygen pressure, SD=standard deviation, SpO_2=saturation				

Table 2: Delirium development status according to the age, carotid cross-clamp times, and the pain scores of the patients.						
Age	**Without delirium (n=79)**		**Postoperative delirium (n=4)**		**U**	**p ***
	Mean ± SD	**Min.- Max.**	**Mean ± SD**	**Min.- Max.**		
	66.87 ± 7.86	48-82	79.25 ± 9.03	67-87	**48.5**	**0.020**
Carotid cross-clamp time (minute)	17.63 ± 5.57	11-35	16.5 ± 6.95	8-25	156.5	0 .974
Pain score (0-10 points)						
PO day 0	0.84 ± 1.55	0-6	3.25 ± 3.94	0-8	100.5 0	0.115
PO day 1	0.16 ± 0.64	0-3	1.75 ± 2.06	0-4	**85.50**	**0.001**
*Mann-Whitney U, PO= postoperative, SD= standard deviation						

The pO_2 levels and delirium development status of the patients after carotid endarterectomy are given in table 3. The mean pO_2 values of the patients who with and without delirium on the postoperative 2-4 hours after carotid endarterectomy were found to be a statistically significant difference (U=44.50; p=0.016; p<0.05). It was determined that the postoperative 0^{th} day pO_2 averages of the patients who developed delirium were low (U=44.50; p=0.016; p<0.05). The pO_2 mean values of the patients who with and without delirium in the 2-4 hours (U=89.00; p=0.211; p>0.05) and night (U=134.50; p=0.643; p>0.05) after carotid endarterectomy were not statistically significant. A weak and significant negative correlation was found between the development of delirium and pO_2 level postoperative in 2-4 hours (r= - 0.267, p= .015).

The mean SpO_2 values of the patients who with and without delirium in the 2-4 hours after carotid endarterectomy were found to be a statistically significant difference (U=40.50; p=0.12; p<0.05). SpO_2 means values within 2-4 hours after carotid endarterectomy were lower in patients who developed delirium compared to other patients. The SpO_2 means values of the patients who with and without delirium in the 12 hours (U=109.00; p=0.297; p>0.05) and in the 24 hours (U=81.50; p=0.104;

p>0.05) after carotid endarterectomy were not statistically significant difference (Table 3). A weak and significant negative correlation was found between the development of delirium and SpO_2 level postoperative in 2-4 hours (r= -0.276, p= .011).

The Hb means values of the patients who with and without delirium on the 0st postoperative day (U=151.00; p=0.882; p>0.05) and on the 1st postoperative day (U=104.00; p=0.255; p>0.05) after carotid endarterectomy were not statistically significant difference. The Htc means values of the patients who with and without delirium on the 0st postoperative day (U=140.00; p=0.702; p>0.05) and on the 1st postoperative day (U=115.00; p=0.361; p>0.05) after carotid endarterectomy were not statistically significant difference.

There was not statistically significant difference in the means Na values of patients who with and without delirium on the 0st postoperative day (U=120.00; p=0.415; p>0.05) and on the 1st postoperative day (U=120.00; p=0.932; p>0.05). There was not statistically significant difference in the means BUN values of patients who with and without delirium on the 0st postoperative day (U=144.00; p=0.765; p>0.05) and on the 1st postoperative (U=144.00; p=0.525; p>0.05).

A statistically significant correlation was found between the nighttime sleep duration of the patients after surgery and the development of delirium (p=0.001; p<0.05). In patients who sleep 4 hours or more, delirium was less common than other patients (Table 4). There was a moderately significant negative correlation between sleeping 4 hours or more on postoperative day 0 and delirium status (r= -0.589, p= .00).

Table 3: Delirium development status according to the pO_2 and SpO_2 levels of the patients.

pO_2 level (mmHg)	**Delirium Status**				**U**	**P***
	Without delirium (n=79)		**Postoperative delirium (n=4)**			
	Mean ± SD	**Min.- Max.**	**Mean ± SD**	**Min.- Max.**		
PO 0st day (2-4 hours)	109.78 ± 22.07	52-139	81.87 ± 11.9	65-90	**44.50**	**0.016**
PO 0 st night (12 hours after surgery)	107.34 ± 17.09	50-133	97.15 ± 21.19	70-116	134.50	0.643
PO 1st day (24 hours after surgery)	103.84 ± 18.33	65.2-132	86.75 ± 25.10	64-120	89.00	0.211
SpO_2 level (%)						
PO 0. day (2-4 hours)	97.49 ± 2.00	86-100	95.32 ± 1.50	93.8-95.32	**40.50**	**0.012**
PO 0 night (12 hours after surgery)	97.71 ± 1.58	89-99.6	96.75 ± 2.01	94.7-98.9	109.00	0.297
PO 1st day (24 hours after surgery)	97.46 ± 1.83	89-99.7	95.37 ± 2.79	92-98.8	81.50	0.104

*Mann-Whitney U, PO=postoperative, pO_2=arterial partial oxygen pressure, SD=standard deviation SpO_2 = saturation

Table 4: Delirium development status of the patients according to the nighttime sleep time on the 0th post operative day.

Night sleep time	**Delirium Status**						
	Without delirium(n=79)			**Delirium (n=4)**	**Total**	**x 2**	**P***
	n	**Percentages (%)**	**n**	**Percentages (%)**			
Less than 4 hours	3	3.6	3	3.6	6	**28.78**	**0.001**
4 hours or more	76	91.6	1	1.2	77		
Total	79	95.2	4	4.8	83		

* Fisher's Exact Test

DISCUSSION

The frequency of delirium and the factors affecting the development of delirium in patients who undergoing ICA endarterectomy were investigated. In our study, delirium was detected in 2.07% (n=4) of the patients after ICA endarterectomy (Table 1). In a study by Böhner et al. to determine the incidence of delirium after vascular surgery, it was found that 3.9% (n=4) of patients who had carotid surgery had delirium (11). In the study by Wan et al.,

the incidence of delirium in geriatric patients with carotid stenosis who undergoing hip replacement surgery was found to be significantly higher (38.90%) than the group without carotid stenosis (7.69%) ($p<0.05$) (9). In a systematic review conducted in the elderly patient group undergoing vascular surgery, it was stated that the incidence of delirium in the group undergoing carotid surgery was between 8-17%.[12] It is thought that the frequency of delirium is low in patients with ICA endarterectomy, due to the provision of cerebral tissue perfusion during the surgery and the administration of oxygen therapy in the postoperative period.

In our study, the mean age of patients with delirium who undergoing ICA endarterectomy (79.25±9.03) was higher than the mean age of patients who did not develop delirium (66.87±7.86), and there was a statistically significant difference ($p=0.02$; $p<0.05$) (tables 1 and 2). A significant and positive weak correlation was found between delirium and age ($r=0.257$, $p= .019$). Studies on different patient groups and meta-analyses in the literature have reported that age affects delirium, and that the rate of delirium development increases as age increases (13,14). In our study, the frequency of delirium development increased as the mean age increased. The ageing brain is subject to neuronal loss, reduced cerebral blood flow, declining dopamine and serotonin levels, and an impaired blood–brain barrier. The impaired blood–brain barrier increases the influence of systematic stress mediators and results in a greater incidence of delirium (4).

In our study, the carotid cross-clamp duration was similar in the group with delirium (16.5±6.95 min) and in the group without delirium (17.63±5.57 min) ($p=0.97$) (table 2). In a randomized controlled study by Xu et al. in patients undergoing carotid endarterectomy, the cross-clamp time was 38 min in the experimental group and 35.5 min in the control group, and there was no statistically significant difference. ($p=0.94$) (8). The fact that the carotid cross-clamp duration was similar indicates that the patients were homogeneous in terms of cerebral perfusion during the surgery.

The mean length of stay in the ICU was found to be 1.09±0.45 days. There was no statistically significant difference between the duration of intubation during the surgery and the length of stay in the ICU in both groups ($p=0.669$; $p>0.05$). In a study, it was found that the length of stay in the ICU increased in the delirium-developing group in patients undergoing vascular surgery (2.9±2.2 days, $p=0.01$) (11). Since delirium-related complications did not develop in patients with delirium, the length of stay in the intensive care unit was similar in all patients.

It was found that there was no significant relationship between gender and development of delirium in ICA endarterectomy patients ($p=1.00$, $p>0.05$). In a study, it was reported that being male increases the risk of delirium after orthopedic surgery (14). In the results of Lee et al.'s research on different patient groups, it was found that the male gender was more common in patients with delirium (15). In a study by Wang et al in patients who had undergone open heart valve surgery, it was stated that male gender had a significant effect on the occurrence of postoperative delirium (6). In our study, no difference was found between the development of delirium according to gender. Since most of the sample was male (80.7%), there may not have been a significant relationship between gender and delirium.

In our study, it was found that there was no significant relationship between the development of delirium according to the type of anesthesia applied during carotid surgery ($p=0.225$; $p>0.05$). In the study conducted by Lee et al. (15) in different patient groups, it was found that no difference between anesthesia types, similar results were found in our study as well ($p= 0.98$). The study by Saller et al. notes that to date there is no scientific answer to the important question of whether a specific anesthetic affects the risk of delirium or even prevents the development of delirium or neurocognitive decline (16). It was determined that there was no significant relationship between the development of delirium according to the anesthesia had been used in patients who undergoing carotid endarterectomy. It is thought that the type of anesthesia applied during carotid surgery was not affect the occurrence of delirium by negatively affecting oxygenation and cerebral perfusion in patients during surgery.

A statistically significant difference was found between the SpO_2 ($U=40.50$; $p=0.12$; $p<0.05$) (table 4) and pO_2 ($U=44.50$; $p=0.16$; $p<0.05$) (table 3) means of the patients who developed and did not develop delirium on the 0th daytime postoperative day. Patients with delirium have lower pO_2 and SpO_2 values than others. In the study by Thisayakorn et al. in elderly patients who undergoing surgery for hip fracture, pO_2 was found to be statistically significantly lower in the delirium group (7). Liu et al. reported that postoperative hypoxia was associated with the development of delirium in patients who had undergoing aortic dissection surgery (17). Cerebral function is extremely susceptible to hypoxemia, as the brain consumes about 20% of the total amount of oxygen supplied to the body (18). In our study, it is thought that delirium developed in patients who developed delirium because cerebral function was affected due to low pO_2 and SpO_2 values.

It was found that the means pain score of the patients with delirium on the 1st postoperative day was statistically significant and high. ($U=85.50$; $p=0.001$; $p<0.05$) (table 2). Mu et al. reported that they reduced the incidence of delirium by reducing postoperative pain (19). While pain causes delirium by causing an acute cerebral stress response, it also exacerbates delirium by causing sleep deprivation in patients (20). It is thought that even the presence of

mild severe pain after surgery causes the development of delirium.

We found that there was a significant relationship between night sleep duration and delirium in patients with ICA endarterectomy patients (table 4). In a cohort study was stated that delirium was a common problem in elderly patients with moderate and severe sleep problems (21). Inadequate sleep is a common condition in ICU patients. Frequent awakenings and an increase in stages 1 and 2 of non-REM with awakenings, difficulty transitioning to stage 3 non-REM or REM sleep occur in ICU patients. Insufficient sleep has been associated with delirium and long-term cognitive impairment (22). Aizawa et al. reduced the incidence of delirium from 35% to 5% by affecting the sleep-wake cycle (23). As the duration of night sleep increases, the rate of delirium development decreases.

Hb values of the patients who developed delirium after carotid surgery and did not develop it on the postoperative 0^{th} day (U=151.00; p=0.882; p>0.05) and the 1^{st} day (U=104.00; p=0.255; p>0.05) no significant difference was found. Ida et al. stated that patients undergoing abdominal surgery, no statistically significant difference was found between postoperative Hb means patients who developed delirium (Hb=12.0± 2.0 g/dL) and those who did not (Hb=12.3±2.0 g/dL). (p= 0.21) [24] In our study, it is thought that it does not constitute a risk factor for delirium since oxygenation is not affected since Hb values are not extremely low (below 12-13 g/dL).

There was no statistically significant difference between the means postoperative BUN values of the patients with and without delirium on the 0^{th} day (U=144.00; p=0.765; p>0.05) and 1^{st} day (U=128.00; p=0.529; p>0.05). In our study, it was thought that BUN values, which were in the normal range, did not affect the formation of delirium, since they did not affect cognitive activities.

Limitations and advantages of this research

This study is important because there are limited studies on determining the incidence of delirium in patients undergoing ICA endarterectomy. Since the research was conducted during the pandemic period, the small sample size may have caused a limitation in the statistical determination of risk factors.

Recommendations or implications for further research

The research can be done in a larger sample group together with different centers.

In conclusion, after ICA endarterectomy, advanced age, low pO_2 and SpO_2, presence of postoperative pain and short sleep duration are risk factors for delirium. In the postoperative period, it is recommended to provide pain control in patients with pharmacological or non- pharmacological methods, to make environmental arrangements in the ICU for the patients to sleep, to prevent noise, and to plan treatment and care hours in a way without disturbing their sleep patterns. Additionally, it is important to closely monitor the pO_2 and SpO_2 values of the patients in the prevention of delirium due to hypoxia, and to perform deep coughing exercises to prevent oxygenation deterioration.

FOOTNOTES

Conflict of interest statement

The authors declare that they have no conflict of interest. No financial support.

Author contributions

Conceptualization: MU, ADE; Data curation: MU, ADE, EK; Formal Analysis: MU, ADE; Investigation: MU, ADE; Methodology: MU, ADE, EK; Project administration: MU, ADE; Resources: MU, ADE; Software: MU, ADE; Supervision: ADE, EK; Validation: MU, ADE; Visualization: MU, ADE; Writing – original draft: MU; Writing – review & editing: MU, ADE

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REFERENCES

1. Aboyans V, Ricco JB, Bartelink MLEL, et al. 2017 ESC guidelines on the diagnosis and treatment of peripheral arterial diseases, in collaboration with the european society for vascular surgery (ESVS). European Heart Journal 2018;39:763–821.
2. Qaja E, Tadi P, Kariyanna PT. Carotid artery steosis. 2021 (online). https://www.ncbi.nlm.nih.gov/books/NBK442025/ access date: 23.04.2023
3. Ge Y, Li Q, Nie Y, et al. Dexmedetomidine improves cognition after carotid endarterectomy by inhibiting cerebral inflammation and enhancing brain-derived neurotrophic factor expression. Journal of International Medical Research 2019;47(6):2471–2482.
4. Swarbrick CJ, Partridge JSL. Evidence-based strategies to reduce the incidence of postoperative delirium: a narrative review. Anaesthesia 2022; 77:92-101.
5. Salluh JIF, Wang H, Schneider EB, et al. Outcome of delirium in critically ill patients; systematic review and meta-analysis. BMJ 2015;350:h2538.
6. Wang H, Guo X, Zhu X, et al. Gender differences and postoperative delirium in adult patients undergoing cardiac valve surgery. Frontiers in Cardiovascular Medicine 2021:1737

7. Thisayakorn P, Tangwongchai S, Tantavisut S, et al. Immune, blood cell, and blood gas biomarkers of delirium in elderly individuals with hip fracture surgery. Dementia and Geriatric Cognitive Disorders 2021:50(2);161-169.
8. Xu N, Li LX, Wang TL, et al. Processed multiparameter electroencephalogram-guided general anesthesia management can reduce postoperative delirium following carotid endarterectomy; A randomized clinical trial. Frontiers in Neurology 2021:12.
9. Wan T, Wei P, Yao Y, Liu H, Li J. Association of carotid plaque and serum lipoprotein-associated phospholipase A2 (LP-PLA2) with postoperative delirium in geriatric patients undergoing hip replacement: a prospective cohort study. Medical Science Monitor 2020:26;e927763.
10. Köse G, Bolu A, Özdemir L, Açıkel C, Hatipoglu S. Reliability and validity of the intensive care delirium screening checklist in Turkish. International Journal of Nursing Knowledge 2016:27(2).
11. Böhner H, Hummel TC, Habel U, et al. Predicting delirium after vascular surgery; a model based on pre- and intraoperative data. Annals of Surgery 2003;238(1):149–156.
12. Raats JW, Steunenberg SL, de Lange DC, van der Laan L. Risk factors of post-operative delirium after elective vasculary surgery in elderly; a systematic review. International Journal of Surgery 2016;35:1-6.
13. Trzepacz PT, Franco JG, Meagher DJ, et al. Delirium phenotype by age and sex in a pooled data set of adult patients. The Journal of Neuropsychiatry and Clinical Neurosciences 2018;30(4):294-301.
14. Yang Y, Zhao X, Gao L, Wang Y, Wang J. Incidence and associated factors of delirium after orthopedic surgery in elderly patients: a systematic review and meta-analysis. Aging Clinical and Experimental Research 2021;33(6):1493-1506.
15. Lee SS, Lo Y, Verghese J. Physical activity and risk of postoperative delirium. Journal of American Geriatrics Society 2019;67:2260-2266.
16. Saller T, Hubig L, Seibold H, et al. Association between post-operative delirium and use of volatile anesthetics in the elderly: a real-world big data approach. Journal of Clinical Anesthesia 2022;83:110957.
17. Liu Z, Pang X, Zhang X, Cao G, Fang C, Wu S. Incidence and risk factors of delirium in patients after type-A aortic dissection surgery. Journal of Cardiothoracic and Vascular Anesthesia 2017;31(6):1996-1999.
18. Slater JP, Guarino T, Stack J, et al. Cerebral oxygen desaturation predicts cognitive decline and longer hospital stay after cardiac surgery. The Annals of Thoracic Surgery 2009;87(1):36-45.
19. Mu DL, Zhang DZ, Wang DX, et al. Parecoxib supplementation to morphine analgesia decreases incidence of delirium in elderly patients after hip or knee replacement surgery; a randomized controlled trial. Anesthesia & Analgesia. 2017;124(6):1992–2000.
20. Lee SY, Liu CY, Wu TY. The effects of pain, agitation, delirium, immobility, and sleep disruption education on novice nurses in adult ICUs. Healthcare 2022;10(8):1538.
21. Ulsa MC, Xi Z, Li P, et al. Association of poor sleep burden in middle age and older adults with risk for delirium during hospitalization. The Journals of Gerontology 2022;77(3):507-516.
22. Pisani MA, Friese RS, Gehlbach BK, et al. Sleep in the ICU. American journal of respiratory and critical care medicine 2015;191(7);731-738.
23. Aizawa K, Kanai T, Saikawa Y, et al. A novel approach to the prevention of postoperative delirium in the elderly after gastrointestinal surgery. Surg Today. 2002;32(4):310–314.
24. Ida M, Takeshita Y, Kawaguchi M. Preoperative serum biomarkers in the prediction of postoperative delirium following abdominal surgery. Geriatrics & Gerontology International 2020;(12);1208-1212.