Original article **UDC: 616.133-007.271-073-089.84:159.95**
doi:10.5633/amm.2018.0303

EFFECT OF CAROTID ARTERY STENTING ON COGNITIVE FUNCTION IN PATIENTS WITH INTERNAL CAROTID ARTERY STENOSIS

Marijana Stošić[1], Marija Andjelković-Apostolović[2,3], Nataša Djindjić[2], Dušica Ilić[1], Saša Ristić[1], Miroslava Živković[2,4], Dragan Stojanov[1,2]

Carotid artery stenting (CAS) is an important therapeutic strategy for patients with carotid artery stenosis. High-grade stenosis of the internal carotid artery is associated with cognitive impairment and decline, even in asymptomatic patients. However, the potential influence of CAS on cognitive function in patients with carotid artery stenosis has not been determined. The aim of this study was to investigate the influence of carotid artery stenting (CAS) on the global cognition in patients with high grade internal carotid stenosis, on various cognitive domains and potential factors that may affect changes of cognitive function in these patients.

This study involved 25 patients with symptomatic and asymptomatic carotid artery stenosis and 25 healthy controls. Patients were evalueted 1 day before procedure and 3 months after procedure. Montreal cognitive assessment (MoCA) was used for the evaluation of cognition.

The MoCA scores of the patients before CAS were significantly lower than that of the control subjects. These scores were significantly higher 3 months after CAS. Also significantly improved after CAS from baseline were scores for an attention, executive functions and memory.

CAS can improve global cognitive function, attention, executive functions and memory in symptomatic and asymptomatic patients with high grade carotid artery stenosis. High cholesterol levels is independent risk factor for deteriorated cognitive functions before revascularization and low educational level is independent factor for poor cognitive performance after revascularization.

Acta Medica Medianae 2018;57(3):23-32.

Key words: *carotid artery stenosis, carotid artery stenting, cognitive function*

[1]Radiology Center, Clinical Center Niš, Niš, Serbia
[2]University of Nis, Faculty of Medicine, Niš, Serbia
[3]Public Health Institute Niš, Niš, Serbia
[4]Clinic of Neurology, Clinical Center Niš, Niš, Serbia

Contact: : Marijana Stošić
Blvd. Dr Zoran Djindjić 48,18000 Niš, Serbia
E-mail: marijanasmb@gmail.com

Introduction

Carotid artery stenosis (CS) is one of the most significant risk factors for ischemic stroke (1, 2). High-grade stenosis of the internal carotid artery is associated with cognitive impairment and decline, even in asymptomatic patients. The pathophysiological causes of cognitive impairment due to carotid artery stenosis include cerebral hypoperfusion and embolic stroke (3, 4). Hypertension, diabetes mellitus, smoking habit, alcohol consumption and cholesterol levels are factors that can predispose to carotid stenosis (5-9).

As a minimally invasive procedure, carotid artery stenting (CAS) is an important therapeutic strategy in carotid artery stenosis (10-14). The effect of carotid artery stenting on cognitive function is unclear. Both cognitive improvement and decline have been reported after CAS (15-20). Reopening a stenotic vessel and restoring blood flow to the brain may improve cognitive dysfunction caused by chronic hypoperfusion. Several authors have therefore suggested that in these patients, carotid revascularisation could imorove cignition (21-23). However, it has also been reported that cognitive function can be negatively affected due to microembolisms caused during the CAS procedure itself, or temporary perfusion defects that may take place during balloon dilatation (15, 24).

Symptomatic status also seems to influence cognitive results in patients after CAS. Some researchers reported that the asymptomatic patients had a poorer cognitive performance after the CAS (25, 26).

The conflicting results of studies testing the ralation betwen carotid revascularisation and changes in cognition have been ascribed to differences between the studies in sample size, type of patients, duration of follow - up, and type of neuropsychological assessment. Little research has been done in this area to date.

The aim of this study was to examine the impact of CAS on global cognition, various domains of cognitive function and the influence of potential factors that might affect cognitive function.

Methods

This prospective observational study was conducted at Radiology Center in Clinical Centre in Niš, between October 2012 and June 2013.

This study involved 25 patients, both symptomatic and asymptomatic who had been diagnosed with carotid artery stenosis (≥ 70%) by Color Doppler ehosonography and MSCT angiography and 25 healthy subjects, who were free of carotid artery stenosis and brain diseases or injuries, as the control .

Patients with symptomatic carotid stenoses had a history of an ipsilateral stroke, at least one transient ischemic attack (TIA) or an episode of amaurosis fugax within previous 6 month. Patients with asymptomatic carotid artery stenosis were defined as having no previous minor stroke or TIA.

Carotid stenosis was diagnosed according to the criteria in the North American Carotid Endarterectomy Trial (NASCET). The decision to treat a given patient was left to Consilium for carotid artery stenosis treatment in Clinical Centre in Nis. Individuals in the control group visited Radiology Center for health screenings during the study period. The healthy participants were selected if they had no history of curent symptoms of ishemic or hemoragic stroke. The participants from control group were matched with pathients in gender, age, educational level, smoking and alcohol consumption. Normal results were shown in all participants from control group for carotid Color Doppler ehosonography. The control group served as a baseline reference for cognitive function, to which patients test group were compared.

Neuropsyhological functions were tested 1 day before and 3 months after CAS and compared with the data of control subjects. Montreal cognitive assessment (MoCA) was used for the evaluation of cognition.

Demographic information was obtained from patients' medical records and by direct interview. Vascular risk factors were estimated in patients and controls following the criteria, which included diabetes mellitus (defined as a glycosylated hemoglobin A1 concentracion > 5.8% or current use of hypoglycaemic agents), hyperlipidemia (total holesrerol concentracion ≥ 220mg/dl or current use of cholesterol-lowering agents), hypertension (defined as systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg or current use of antihypertensive medication), tobacoo smoking and alcohol consumption.

The exclusion criteria included present serious medical, psyhiatric and neurologic disorders.

All the subjects agreed to join the research, gave their written informed consent and had the right to withdraw at any time.

Cognitive assessment

MoCA is a brief screening tool assessing visiuospatial and executive functions, attention, short-term memory, language and orientation, has been translated and adapted into several languages and is available freely on the Internet:

(http://www.mocatest.org) (27).

The MoCA assesses global cognitive function and contains of 10 subtests: an alternating trail test, cube copying, clock-drawing, naming, attention, sentence repeating, verbal fluency, abstraction, auditory-verbal learning test (AVLT)-delayed recall, and orientation. Visuospatial abilities are assessed using a clock-drawing task and a three-dimensional cube copy, short-term memory is tested with two learning trials of five nouns followed by a delayed recall task. Executive functions are assessed using a task adapted from the Trail Making B test, a phonemic fluency task, and a two-item verbal abstraction task. Attention, concentration, and working memory are evaluated using an attention task, a serial sub traction task and digits forward and backward. Language is tested with a naming task with low-familiarity animals (lion, camel and rhinoceros), repetition of two syntactically complex sentences, and the fluency task. Orientation is evaluated by time and place.

The total scores of the MoCA scale is 30 and the higher the score, the better the cognition. In the evaluation, a score of > 26 was regarded normal, and an additional 1 point was added when the duration of education was ≤ 12 years (28). The participants in our study were evaluated with the Serbian MoCA, version 7.1.

CAS procedure

Before CAS, detection of coagulation function, routine blood test and electrocardiography were performed and patients were treated with oral aspirin at 100 mg/d and oral clopidogrel at 75 mg/d 7 days before the procedure. Following focal anesthesia, Seldinger technique was used to puncture the right femoral artery, and a 6F vascular sheath was used, followed by insertion of a 6F catheter. Under the guidance of a wire, the catheter was inserted to the proximal part of the lesioned vessel. Heparin (5000 U) was intravenously injected for systemic heparinization. Under the guidance of a road map, a protective umbrella was carefully inserted through the stenotic site, and a stent was then inserted along the umbrella. After accurately locating the stent, the stent was released. The balloon was selected according to the degree of stenosis, and then the umbrella was expanded, followed by retraction of the umbrella and performance of radiography. On the day of intervention, aspirin and clopidogrel were administered, and the doses were identical to those before intervention.

Statistical analysis

Statistical analyses were conducted using IBM SPSS Statistics 20.0. Quantitative data are expressed as mean ± standard deviation, and qualitative data as proportion (%). Student t test was used to compare two means, but in situations when there was not normally distributed data Z-Mann-Whitney U test was used. Z-Wilcoxon Rang test was used to compare two related samples. Linear regression analisis was used to determinate risk factors. A value of $P < 0.05$ was considered statistically significant.

Results

There were no neurological complications during the procedure or during hospitalization in any patient. The procedure was completed with technical success in all patients. The degree of stenosis was significantly reduced after CAS. All 25 patients completed 3 month follow up.

The demographic data of the stent treatment and control subjects are listed in Table 1. Average age was 69,32 ± 7,59 year, the youngest participant was 57 and the oldest 82 years old. There were no statistical difference in:

- gender (χ^2 = 0,333; p = 0,564),
- age (t = 0,464; p = 0,645) and
- educational level (χ^2 = 2,508; p = 0,285) betwen groups (Table1.). There was no statistical difference in bad habits betwen groups:
- smoking (χ^2 = 1,471; p = 0,225) and
- alcohol consumption (χ^2 = 0,365; p = 0,544)

(Table 2.). 6 patients had hypertension (24%), 13 (52%) had diabetes mellitus and 2 of then were on insulin, 17(68%) patients had high cholesterol levels. In control group 12 participants had hypertension (48%), 5 had diabetes mellitus and one of them was on insulin (4%), 6 participants had high cholesterol levels (24%).

There was no statistical difference in vascular risk factors between groups:

- hypertension (χ^2 = 3,125; p = 0,077) and
- diabetes mellitus (χ^2 = 5,600; p = 0,061),

but there were heir levels of cholesterol among patients than control group (χ^2 = 3,125; p = 0,002) (Table 3.).

Table 1. Demographic data of the stent treatment group and control group

		Patients	Controls	χ^2/t*	P
Gender	**Women n (%)**	16 (64,0)	14 (56,0)	0,333	0,564
	Men n (%)	9 (36,0)	11 (44,0)		
Age	$\bar{X}$±SD	69,32 ± 7,59	68,4 ± 4,95	0,464	0,645
Education	**Elementary n (%)**	11 (44,0)	8 (32,0)	2,508	0,285
	High school n (%)	14 (56,0)	15 (60,0)		
	Faculty n (%)	0 (0,0)	2 (8,0)		

Table 2. Distribution of bad habits in stent treatment and control group

		Patients	Controls	χ^2	P
Smoking	**No n(%)**	19 (76,0)	15 (60,0)	1,471	0,225
	Yes n(%)	6 (24,0)	10 (40,0)		
Alcohol	**No n(%)**	18 (72,0)	16 (64,0)	0,368	0,544
	Yes n(%)	7 (28,0)	6 (36,0)		

Table 3. Comorbidity distribution among groups

		Patients	Controls	χ^2	P
HA	**no n(%)**	19 (76,0)	13 (52,0)	3,125	0,077
	yes n(%)	6 (24,0)	12 (48,0)		
DM	**no n(%)**	12 (48,0)	20 (80,0)	5,600	0,061
	oral diabetic's n(%)	11 (44,0)	4 (16,0)		
	insulin n(%)	2 (8,0)	1 (4,0)		
Cholesterol	**Normal levels**	8 (32,0)	19 (76,0)	9,742	0,002
	High levels	17 (68,0)	6 (24,0)		

There were 15 symptomatic (60%) and 10 asymptomatic (40%) patients. All patients had ≥70% stenosis, 19 had 70-80% (76%) and 6 had subocclusion (24%). 14 patients (56%) had right side stenosis, 8 (32%) had left side stenosis and 3 (12%) had both side stenosis.

The values of the total MoCA scor and various cognitive domains in patients before intervention and the control group are shown In Table 4. There was statistical difference among these functions which were significantly lower in patients with carotid artery stenosis than in control group:

- visuospatial abilities (Z = 3,896; p < 0,001),
- attention (Z = 3,082; p < 0,002),
- language (Z = 5,103; p < 0,001), and
- memory (Z = 5,151; p < 0,001).

Total MoCA score was significantly heir among control group (Z = 5,711; p < 0,001). Comparing separately various cognitive function and total MoCA score among patients before and after intervention statistically significant different were:

- attention (Z = 3,080; p = 0,002),
- executive functions (Z = 2,762; p = 0,006),
- memory (Z = 3,793; p < 0,001) and
- total MoCA score (Z = 4,455; p < 0,001).

All these functions were statistically hair after CAS intervention (Table5.).

Comparing separately various cognitive functions and total MoCa score in asymptomatic patients before and after intervention statistically significant different were:

- attention (Z = 2,070; p = 0,038),
- executive functions (Z = 2,000; p = 0,046),
- memory (Z = 2,810; p = 0,005) and
- total MoCA score (Z = 2,877; p = 0,004).

All of these functions were statistically heir after intervention (Table 6.).

Table 4. Cognitive function and total MoCA score comparing among patients and control group before CAS intervention

Functions	Patients	Controls	Z	P
Visuospatial	4,28 ± 0,89	5,00 ± 0,00	3,896	< 0,001
Attention	4,60 ± 0,87	5,36 ± 0,70	3,082	0,002
Language	1,24 ± 0,78	2,52 ± 0,51	5,103	< 0,001
Executive functions	1,32 ± 0,85	1,76 ± 0,44	1,866	0,062
Memory	2,40 ± 1,04	4,28 ± 0,68	5,151	< 0,001
Orientation	6,00 ± 0,00	6,00 ± 0,00	0,000	1,000
Total MoCA score	23,24 ± 2,65	28,16 ± 0,94	5,711	< 0,001

Z- Mann-Whitney U test

Table 5. Cognitive function and total MoCA score comparing in patients before and after CAS intervention

Cognitive function	Before CAS	After CAS	Z	P
Visuospatial	4,28 ± 0,89	4,28 ± 0,97	0,000	1,000
Attention	4,60 ± 0,87	5,32 ± 0,80	3,080	0,002
Language	1,24 ± 0,78	2,52 ± 0,51	0,789	0,425
Executive functions	1,32 ± 0,85	1,80 ± 0,40	2,762	0,006
Memory	2,40 ± 1,04	3,44 ± 0,87	3,793	< 0,001
Orientation	6,00 ± 0,00	6,00 ± 0,00	0,000	1,000
Total MoCA score	23,24 ± 2,65	25,76 ± 2,22	4,455	< 0,001

Z- Wilcoxon Rang test

Table 6. Cognitive function and total MoCA score comparing among asymptomatic patients before and after CAS intervention

Cognitive function	Before CAS	After CAS	Z	P
Visuospatial	4,20 ± 1,03	4,20 ± 1,03	0,000	1,000
Attention	4,60 ± 0,97	5,50 ± 0,53	2,070	0,038
Language	1,20 ± 0,79	1,30 ± 0,53	0,378	0,705
Executive functions	1,40 ± 0,84	1,80 ± 0,42	2,000	0,046
Memory	2,50 ± 1,08	3,60 ± 0,84	2,810	0,005
Orientation	6,00 ± 0,00	6,00 ± 0,00	0,000	1,000
Total MoCA score	23,30 ± 2,65	25,80 ± 1,93	2,877	0,004

Z- Wilcoxon Rang test

Comparing various cognitive domains and total MoCA scor among symptomatic patiens before and after intrvention statisticaly significant diferent were:

- attention (Z = 2,310; p = 0,021),
- executive functions (Z = 2,070; p = 0,036),
- memory (Z = 2,683; p= 0,007) and
- total MoCA scor (Z = 3,453; p = 0,001).

All functions were significantly hier after intervention (Table 7.).

The results of univariant linear regression of risk factors before intervention are shown in Table 8. Statistically significant independent risk factors were diabetes mellitus (Beta = -0,293; p = 0,039) and cholesterol levels (Beta = -0,439; p = 0,002). Diabetes mellitus and high cholesterol levels are predictors of lower results for total MoCA score before intervention. In multivariante model independent variables were studied: diabetes mellitus and cholesterol levels as significant risk factors for lower levels of MoCA score before intervention. Only cholesterol is statistically significant risk factor in this model for lower cognitive function results before CAS (Beta = -0,383; p = 0,006) (Table 9.).

Table 7. Cognitive function and total MoCA score in symptomatic patients before and after CAS intervention

Cognitive function	Before CAS	After CAS	Z	P
Visuospatial	4,33 ± 0,82	4,33 ± 0,82	0,000	1,000
Attention	4,60 ± 0,83	5,20 ± 0,94	2,310	0,021
Language	1,27 ± 0,79	1,47 ± 0,74	0,828	0,408
Executive functions	1,27 ± 0,88	1,80 ± 0,42	2,070	0,038
Memory	2,33 ± 1,05	3,33 ± 0,89	2,683	0,007
Orientation	6,00 ± 0,00	6,00 ± 0,00	0,000	1,000
Total MoCA score	23,20 ± 2,75	25,73 ± 2,46	3,453	0,001

Z- Wilcoxon Rang test

Table 8. Univariant linear regression of patient's risk factors for total MoCA score before CAS intervention

	Unstandardized Coefficients		Standardized Coefficients	95% CI for B	P
	B	SG	Beta		
Gender	0,750	0,918	0,117	-1,096 - 2,596	0,418
Age	-0,110	0,070	-0,220	-0,251 - 0,031	0,124
Education	1,570	0,789	0,276	-0,016 - 3,157	0,052
HT	0,816	0,936	0,125	-1,067 - 2,6999	0,388
DM	-1,524	0,718	-0,293	-2,968 - 0,079	**0,039**
Smoking	1,728	0,939	0,257	-0,159 - 3,615	0,072
Alcohol	0,441	0,969	0,066	-1,507 - 2,390	0,651
Cholesterol	-2,746	0,818	-0,436	-4,390 - 1,101	**0,002**
Symptomatic	0,120	1,322	0,019	-2,615 - 2,854	0,929
Left/right side	1,678	1,257	0,268	-0,923 - 4,278	0,195
stenosis grade%	0,147	1,516	0,020	-2,990 - 3,284	0,924

CI-Confidence interval

Table 9. Multivariante linear regression of risk factors for total MoCA score before CAS intervention

	Unstandardized Coefficients		Standardized Coefficients	95% CI for B	P
	B	SG	Beta		
DM	-0,947	0,700	-0,182	-2,356 - 0,461	0,183
Cholesterol	-2,415	0,847	-0,383	-4,119 - 0,710	**0,006**

Table 10. Univariant linear regression of risk factors for total MoCA score after CAS intervention

	Unstandardized Coefficients B	Unstandardized Coefficients SG	Standardized Coefficients Beta	95% CI for B	P
Gender	0,543	0,930	0,121	-1,380 - 2,466	0,656
Age	-0,157	0,056	-0,447	-0,291 - -0,022	**0,025**
Education	1,676	0,755	0,420	0,116 - 3,237	**0,036**
HT	0,899	0,937	-0,196	-2,838 - 1,040	0,347
DM	-0,466	0,755	-0,128	-2,027 - 1,095	0,543
Smoking	1,509	0,983	-0,013	-2,096 - 1,973	0,119
Alcohol	-0,855	0,927	0,015	1,851 - 1,984	0,353
Cholesterol	0,067	0,818	-0,436	-4,390 - 1,101	0,943
Symptomatic	0,067	0,927	0,015	-1,851 - 1,984	0,943
Left/right side	1,195	0,880	0,272	-0,626 - 3,016	0,188
stenosis grade%	0,096	1,063	0,019	-2,103 - 2,296	0,928

Table 11. Multivariante linear regression of risk factors for total MoCA score after CAS intervention

	Unstandardized Coefficients B	Unstandardized Coefficients SG	Standardized Coefficients Beta	95% CI for B	P
Age	-0,947	0,700	-0,182	-2,356 - 0,461	0,183
Education	-2,415	0,847	-0,383	-4,119 - 0,710	**0,006**

The results of univariant linear regression analysis of risk factors for total MoCA score after intervention are shown In Table 10. Statistically significant independent risk factors were:

- age (Beta = -0,447; p = 0,025) and
- education level (Beta = 0,420; p = 0,036).

Older patients and lower education are predictors of lower levels for total MoCA scores after intervention. In multivariante model independent variables were studied: age and educational level as statistically significant risk factors for lower total MoCA score after CAS intervention. Only educational level is statistically significant factor in this model for lower cognitive function after CAS
(Beta = -0,383; p = 0,006) (Table 11.).

Discussion

Examination of the demographic and social characteristics of the patients with high grade stenosis in the present study revealed that high blood pressure was the most common vascular risk factor, followed by diabetes and high cholesterol levels. These findings are in line with those of other studies (29). Scores were evaluated relative to those of healthy individuals matched for age, gender, bad habits and educational level. We found that participants from control group had also hypertension, diabetes mellitus and high cholesterol levels which suggest that control group also had high vascular risk factors. In other studies participants from control group were patients with various levels of carotid artery stenosis and high vascular risk factors or healthy participants without vascular risk factors (25, 29-33).

Patients with high grade carotid artery stenosis had significantly poorer scores on cognitive tests than control subjects. The results in our study showed baseline differences between patients and controls in certain cognitive domains. We found that visuospatial abilities, attention, language and memory are lower in patients than controls. We found no significant change in other cognitive domains.

The primary objective of this observational prospective study was to determine the effect of CAS on cognition in patients with high grade artery stenosis. We found that total MoCA score before and after CAS was significantly different. Three months after intervention patients showed significantly better cognition. The results in our study are in accordance with the results from previous reports that have shown improvements in cognitive function in patients treated with stent placement or surgery for carotid artery stenosis (29-33).

We found that certain domains of cognition improved after revascularization. 3 month after CAS our patients reached better scores on test of attention, executive functions and memory. Other researches also reported improvement in executive functions and memory (34). Most studies failed to demonstrate a clear benefit of CAS on various cognitive functions (29-33).

Our secondary objective in the present study was to determine the factors that may affect changes in cognitive function in these patients. It has been reported previously that gender, older age, and little educational level are risk factors for cognitive deterioration, whereas hyperlipidemia, diabetes mellitus, smoking or drinking are controversial (33). Other researchers reported that potential risk factors for deteriorated MoCA scores 3 years after CAS were age > 65 y; little education; and hypertension (35, 36). It was reported that carotid atherosclerosis is an independent vascular risk factor for cognitive impairment in nonstroke patients. It can not only impair the subtle general cognitive function but also decrease the specific domain such as memory, motor function, visual perception, attention, and executive function, which are still on studying (37). Linear regression analyses in our study showed that before CAS diabetes mellitus and cholesterol levels were independent risk factors for lower total MoCA scores and that age, educational level and bad habits did not influence on cognition before intervention. After CAS age and educational level were independent risk factors for lower total MoCA scores.

Some studies have investigated side-specific cognitive effects. It is generally assumed that restoration of hemodynamic on the treated side will be more beneficial to the cognitive function of the ipsilateral cerebral hemisphere (25, 26, 29). We found no differences in cognitive functions considering the side of carotid artery stenosis.

Symptomatic status also seems to influence cognitive results in patients after CAS (29). Most of the studies were carried out in patients with symptomatic stenosis, only few of them followed asymptomatic patients (23, 31). The changes in cognitive performance of symptomatic and asymptomatic CS patients were analyzed in this study in a prospective manner by testing their cognitive function be¬fore and after the CAS procedure. Both symptomatic and asymptomatic patients showed better results for attention, executive functions and memory after CAS. Some researchers reported that the asymptomatic patients had a poorer cognitive performance after the CAS (25, 26, 38). We can conclude that symptomatic status does not have a clear impact on the cognition after carotid revascularization.

The discrepancies in literature reports on cognitive function can also be explained by differences in methodological factors such as battery of neuropsychological testing, sample size and use of control population, severity of carotid stenosis and time to post-interventional follow-up.

Conclusion

CAS can improve global cognitive function, attention, executive functions and memory in symptomatic and asymptomatic patients with high grade carotid artery stenosis. There was no positive effect on visuospatial abilities and language but CAS was not associated with a decline in any area of cognitive function. High cholesterol levels is independent risk factor for deteriorated cognitive functions before revascularization and low educational level is independent factor for poor cognitive performance after revascularization . Symptomatic status does not have a clear impact on the cognition before and after carotid revascularization.

Future studies in larger groups of patients are probably needed to fully investigate the long-term effect of CAS on cognition in patients with carotid artery stenosis.

References

1. Inzitari D, Eliasziw M, Gates P, Sharpe BL, Chan RKT, Meldrum HE, et al. The causes and risk of stroke in patients with asymptomatic internal-carotid-artery stenosis. N Engl J Med 2000; 342(23): 1693-700. [CrossRef][PubMed]
2. Rosamond W, Flegal K, Friday G, Furie K, Go A, Greenland K, et al. Heart disease and stroke statistics–2007 update: a report from the American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Circulation 2007; 115: e69-171. [CrossRef][PubMed]
3. Ishiara H, Fumiaki O, Shirao S, Kato S, Sadahiro H, Masami O, et al. Cognitive outcome differences on the side of carotid artery stenting. Journal of Vascular Surgeru 2013; 57: 125-30. [CrossRef][PubMed]
4. Blaco-Rojas L, Arboix A, Canovas D, Grau-Olivares M, Morera JCO, Parra O. Cognitive profile in patients with a first-ever lacunar infarct with and without silent lacunes: a comparative study. BMC Neurology 2013; 13: 203. [CrossRef][PubMed]
5. Ortega G, Alvarez B, Quintana M, Yugueros X, Alvarez-Sabin J, Matas M. Asymptomatic carotid stenosis and cignitive improvement using transcervical stenting with protective flow reversal tehnique. European Journal of Vascular and Endovascular Surgery 2014; 47: 585-92. [CrossRef][PubMed]
6. Van Dijk EJ, Prins ND, Vrooman HA, Hofman A, Koudstaal PJ, Breteler MM. Progression of cerebral small vessel disease in relation to risk factors and cognitive consequences: Rotterdam Scan Study. Stroke 2008; 39: 2712-9. [CrossRef][PubMed]
7. Liu W, Liu R, Sun W, Peng Q, Zhang W, Xu E, et al. Different impacts of blood pressure variability on the progression of cerebral microbleeds and white matter lesions. Stroke 2012; 43: 2916-22. [CrossRef][PubMed]
8. Benavente OR, Coffey CS, Benavente MF, Caiwit R, Hart RG, McClure LA, et al. The secondary prevention of small subcortical strokes (SPS3) Trial: results of the blood pressure intervention. Lancet 2013; 382: 507-15. [PubMed]
9. Allerhand M, Doubal FN, Hernandez MV, Morris Z, Gow AJ, Bastin M, et al. Vascular risk factors, large-artery atheroma, and brain white matter hyperintensities. Neurology 2014; 82: 1331-8. [CrossRef][PubMed]
10. Arboix A. Cardiovascular risk factors for acute stroke: Risk profiles in the different subtypes of ischemic stroke. World J Clin Cases 2015; 3: 418-29. [CrossRef][PubMed]
11. Saw J. Carotid artery stenting for stroke prevention. Can J Cardiol 2014; 30: 22–34. [CrossRef][PubMed]
12. Witt K, Borsch K, Daniels C, Walluscheck K, Alfke K, Jansen O, et al. Neuropsychological consequences of endarterectomy and endovascular angioplasty with stent placement for treatment of symptomatic carotid stenosis – a prospective randomised study. J Neurol 2007; 254:1524-32. [CrossRef][PubMed]
13. Paraskevas KI, Lazaridis C, Andrews CM, Veith FJ, Giannoukas AD. Comparison on cognitive function after carotid artery stenting versus carotid endarterectomy: European Journal of Vascular and Endovascular Surgery 2014; 47: 221-31. [CrossRef][PubMed]
14. Safian RD, Bresnahan JF, Jaff MR, Foster M, Bacharah JM, Maini B, et al. Protected carotid stenting in high-risk patients with severe carotid artery stenosis. J Am Coll Cardiol 2006; 47: 2384-9. [CrossRef][PubMed]
15. Zahn R, Ischinger T, Hochadel M, Zeymer U, Schmalz W, Treese N, et al. Carotid artery stenting in octogenarians: results from the ALKK Carotid Artery Stent (CAS) registry. Eur Heart J 2007; 28: 370-5. [CrossRef][PubMed]
16. Zhou W, Hitchner E, Gillis K, Sun L, Floyd R, Lane B, et al. Prospective neurocognitive evaluation of patients undergoing carotid interventions. J Vasc Surg 2012; 56: 1571-8. [CrossRef][PubMed]
17. Mudra JLH, Staubach S, Hein-Rothweiler R, Segerer M, Strohm H, Weber H, et al. Long-Term Outcomes of Carotid Artery Stenting in Clinical Practice. Circ Cardiovasc Interv 2016; 9: e003940. [CrossRef][PubMed]
18. Ortega G, Alvarez B, Quintana M, Ribo M, Matas M, Alvares-Sabin J, et al: Cognitive improvement in patients with severe carotid artery stenosis after transcervical stenting with protective flow reversal. Cerebrovasc Dis 2013; 35: 124-30. [CrossRef][PubMed]
19. Gaudet JG, Meyers PM, McKinsey JF, Lavine SD, Gray W, Mitchell E, et al: Incidence of moderate to severe cognitive dysfunction in patients treated with carotid artery stenting. Neurosurgery 2009; 65: 325-9. [CrossRef][PubMed]
20. De Rango P, Caso V, Leys D, Paciaroni M, Lenti M, Cao P, et al. The role of carotid artery stenting and carotid endarterectomy in cognitive performance: a systematic review. Stroke 2008; 39:3116-3127. [CrossRef][PubMed]
21. Ghogawala Z, Westerveld M and Amin-Hanjani S. Cognitive outcomes after carotid revascularization: the role of cerebral emboli and hypoperfusion. Neurosurgery 2008; 62: 385-95. [CrossRef][PubMed]
22. Plessers M, Van Herzeele I, Vermassen F, Vingerhoets G. Neurocognitive functioning after carotid revascularization: a systematic review. Cerebrovasc Dis Extra 2014; 4: 132-48. [CrossRef][PubMed]
23. Picchetto L, Spalletta G, Casolla B, Cacciari C,Cavallari M, Fantozzi C, et al. Cognitive Performance following Carotid Endarterectomy or Stenting in Asymptomatic Patients with Severe ICA Stenosis Cardiovascular Psychiatry and Neurology 2013; ID 342571. [CrossRef]
24. Lin MS, Chiu MJ, Wu YW, Huang CC, Chao CC, Chen YH, et al. Neurocognitive improvement after carotid artery stenting in patients with chronic internal carotid artery occlusion and cerebral ischemia. Stroke 2011; 42: 2850-4. [CrossRef][PubMed]
25. Yoon BA, Sohn SW, Cheon SM, Kim DH, Cha JK, Yi SJ, et al. Effect of carotis artery stenting of cognitive function in patients with carotid artery stenosis: 3 month folow up study: J Clin Neurol 2015; 11: 149-56. [CrossRef][PubMed]
26. Brand N, Bossema ER, Ommen MvM, Moll FL, Ackerstaff RG. Left or right carotid endarterectomy in patients with atherosclerotic disease: ipsilateral effects on cognition? Brain Cogn 2004; 54: 117-23. [CrossRef][PubMed]
27. Nasreddine ZS, Phillips NA, Bedirian V, Charbonneau S, Whitehead V, Collin I, et al. The Montreal Cognitive Assessment, MoCA:A brief screening tool for mild

cognitive impairment. J Am Geriatr Soc 2005; 53: 695-9. [CrossRef][PubMed]

28. Borlanda E, Naggaa K, Nilssonc PM, Minthona L, Nilssona ED, Palmqvista S. The Montreal Cognitive Assessment: Normative data from a large Swedish population-based cohort journal of Alzheimer's disease 2017; 59: 893-901. [PubMed]
29. Cheng Y, Wanng YJ, Yan JC, Zhou R, Zhou HD. Effects of carotid artery stenting on cognitive function in patients with mild cognitive impairment and carotid stenosis. Experimental and therapeutic medicine 2013; 5: 1019-24. [CrossRef][PubMed]
30. Wang T, Sun D, Liu Y, Mei B, Li H, Zhang S, et al. The impact of carotid artery stenting on cerebral Perfusion, Functional connectivity, and cognition in severe asymptomatic carotid stenosis Patients. Frontiers in Neurology 2017; 8: 403. [CrossRef][PubMed]
31. Grunwald IQ, Papanagiotou P, Reith W, Backens M, Supprian T, Politi M, et al. Influence of carotid artery stenting on cognitive function. Neuroradiology 2010; 52:61-6. [CrossRef][PubMed]
32. Wang T, Mei B, Zhang J. Atherosclerotic carotid stenosis and cognitive function. Clin Neurol Neurosurg 2016; 146: 64-70. [CrossRef][PubMed]
33. Sun QJ, Xia YZ, Qu CQ, Ruan XZ, Li JF, Cong L, et al. Carotid Artery Stenting Ameliorates the Cognitive Impairment in Patients with Leukoaraiosis, the Ischemic Change of Cerebral White Matter. Tohoku J Exp Med 2014; 233: 257-64. [CrossRef][PubMed]
34. Mendi OA, Sposato LA, Fabb N, Lev, Call A, Valdivieso LR, et al. Improvement in executive function after unilateral carotid artery stenting for severe asymptomatic stenosis. J Neurosurg 2012; 116: 179-84. [CrossRef][PubMed]
35. Piccinin AM, Muniz-Terrera G, Clouston S, Reynolds CA, Thorvaldsson V, Deary IJ, et al. Coordinated analysis of age, sex, and education effects on change in MMSE scores. J Gerontol B Psychol Sci Soc Sci 2013; 68: 374-90. [CrossRef][PubMed]
36. Yan Y, Yuan Y, Liang L, Chen T, Shen Y, Zhong C. Influence of carotid artery stenting on cognition of elderly patients with severe stenosis of the internal carotid artery. Med Sci Monit 2014; 20: 1461-68. [CrossRef][PubMed]
37. Chen WH, Jin W, Lyu PY, Liu Y, Li R, Hu M, et al. Carotid atherosclerosis and cognitive impairment in nonstroke patients. Chin Med J 2017; 130:2375-9. [PubMed]
38. Mathiesen EB, Waterloo K, Joakimsen O, Bakke SJ, Jacobsen EA, Bonaa KH. Reduced neuropsychological test performance in asymptomatic carotid stenosis: The Tromso Study. Neurology 2004; 62:695-701. [CrossRef][PubMed]

Originalni rad **UDC: 616.133-007.271-073-089.84:159.95**
doi:10.5633/amm.2018.0303

EFEKTI KAROTIDNOG STENTINGA NA KOGNITIVNE FUNKCIJE KOD BOLESNIKA SA STENOZOM KAROTIDNE ARTERIJE

Marijana Stošić[1], Marija Anđelković-Apostolović[2,3], Nataša Đinđić[2], Dušica Ilić[1], Saša Ristić[1], Miroslava Živković[2,4], Dragan Stojanov[1,2]

[1]Centar za radiologiju, Klinički centar Niš, Niš, Srbija
[2]Univerzitet u Nišu, Medicinski fakultet, Niš, Srbija
[3]Institut za javno zdravlje u Nišu, Niš, Srbija
[4]Klinika za neurologiju, Klinički centar Niš, Niš, Srbija

Kontakt: Marijana Stošić
Bulevar Dr Zorana Đinđića 48, 18000 Niš, Srbija
E-mail: marijanasmb@gmail.com

Stenting karotidne arterije (CAS) je značajan terapijski modalitet kod pacijenata sa stenozom karotidne arterije. Stenoza unutrašnje karotidne arterije visokog stepena dovodi do poremećaja i deficita kognitivnih funkcija, čak i kod asimptomatskih bolesnika. Potencijalni uticaj stentiranja karotidne arterije na kognitivne funkcije bolesnika sa stenozom karotidne arterije nije dovoljno istražen. Cilj ovog istraživanja bio je da se ispita uticaj karotidnog stentinga na kognitivne funkcije kod bolesnika sa stenozom karotidne arterije visokog stepena, na različite kognitivne domene, kao i na potencijalne faktore koji mogu uticati na kognitivne funkcije kod ovih bolesnika.

U studiju je uključeno 25 bolesnika sa simptomatskom i asimptomatskom stenozom karotidne arterije i 25 zdravih ispitanika. Kognitivne funkcije su evaluirane jedan dan pre procedure i tri meseca nakon procedure. Za evaluaciju kognitivnih funkcija korišćen je Montreal cognitive assessment (MoCA)-test.

Ukupan MoCA skor kod bolesnika pre intervencije bio je značajno niži u odnosu na kontrolnu grupu. Ovaj skor je značajno povišen tri meseca nakon intervencije. Značajano su se popravili rezultati za pažnju, egzekutivne funkcije i pamćenje.

Karotidni stenting može poboljšati ukupne kognitivne funkcije kao i pažnju, egzekutivne funkcije i pamćenje kod simptomatskih i asimptomatskih bolesnika sa stenozom karotidne arterije visokog stepena. Visok nivo holesterola predstavlja nezavisni faktor rizika za deficit kognitivnih funkcije pre revaskularizacije, dok nizak nivo obrazovanja predstavlja nezavistan faktor za nizak nivo kognitivnih funkcija nakon revaskularizacije.

Acta Medica Medianae 2018;57(3):23-32.

Ključne reči: *stenoza karotidne arterije, karotidni stenting, kognitivne funkcije*