Turkish Journal of Vascular Surgery 2021;30(2):102-106

DOI: 10.9739/tjvs.2021.924
www.turkishjournalofvascularsurgery.org

Original Article

Can ankle-brachial index be used as a predictor for carotid artery shunt application during carotid endarterectomy?

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ABSTRACT

Objectives: This study aims to investigate the possible relationship between low ankle-brachial index (ABI) and shunt requirement during carotid endarterectomy (CEA) operations.

Patients and methods: Medical records of a total of 56 patients (40 males, 16 females; mean age: 65.6±8.4 years; range, 48 to 82 years) who underwent CEA between January 2013 and December 2016 were retrospectively reviewed. The ABI was measured in all patients at the time of hospital admission. Peripheral arterial disease was defined as having an ABI of ≤0.90 in either leg. Selective carotid artery shunt strategy was applied to all patients who underwent CEA under regional anesthesia.

Results: Forty-eight (85.8%) patients were symptomatic. Peripheral arterial disease was diagnosed in 25 (44.6%) patients with ABI measurements. Eleven (19.6%) patients required shunt placement due to neurological deterioration during the carotid clamping test. The mean ABI of 11 (19.6%) patients was 0.8±0.15, while the ABI was less than 0.90 in 10 (17.8%) patients. There was a statistically significant correlation between perioperative shunt usage and peripheral arterial disease (odds ratio [OR]: 19.68, 95% confidence interval [CI]: 2.3-164.4; p=0.001).

Conclusion: Low ABI appears to be related to a higher rate of shunt requirement in patients undergoing CEA under regional anesthesia with a selective shunt strategy in our modest cohort.

Keywords: Ankle-brachial index, carotid artery shunting, carotid endarterectomy.

Shunt use in carotid endarterectomy (CEA) is still controversial. Some surgeons advocate routine use of shunt to reduce the risk of cerebral hypoperfusion during procedure,[1,2] whereas some others do not recommend shunt application, as cerebral hypoperfusion rarely causes perioperative stroke and carotid artery dissection, and injury or distal embolism may occur, while placing the shunt.[3,4] Besides, there is another group of physicians who prefer insertion of shunts only in patients having neurophysiological instability or insufficient carotid arterial backflow during the clamping test of the ipsilateral internal carotid artery (ICA). The selective shunting is beneficial for high-risk patients and also prevents the potential complications in low-risk patients.[2]

Received: January 06, 2021 ***Accepted:*** February 28, 2021 ***Published online:*** March 24, 2021

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Citation:
Önalan MA, Öztaş DM, Önalan A, Beyaz MO, Bahseliyev S, Sungur Z, et al. Can ankle-brachial index be used as a predictor for carotid artery shunt application during carotid endarterectomy? Turk J Vasc Surg 2021;30(2):102-106

Low ankle-brachial index (ABI) dependably recognizes peripheral arterial disease (PAD) and is also one of the non-invasive markers of atherosclerosis.[5,6] Peripheral arterial disease has shown to be an indicator of other arterial diseases in several cross-sectional and prospective studies and it increases the risk of incidental ischemic stroke as two- to three-fold.[7,8]

Recent data have shown that low ABI is related to an increased risk of recurrent vascular events in patients diagnosed with acute ischemic stroke or transient ischemic attack (TIA).[9,10] To the best of our knowledge, the prognostic value of decreased ABI has not been examined yet in the literature to identify neurophysiological instability during CEA. In the present study, therefore, we aimed to investigate the possible relationship between low ABI and shunt requirement in patients undergoing CEA with a selective shunting strategy.

PATIENTS AND METHODS

This single-center, retrospective study was conducted at Istanbul University Faculty of Medicine, Department of Cardiovasculer Surgery between January 2013 and December 2016. Medical records of 56 consecutive patients (40 males, 16 females; mean age: 65.6±8.4 years; range, 48 to 82 years) who underwent CEA under regional anesthesia were retrospectively reviewed. The patients were routinely evaluated preoperatively by carotid Doppler ultrasonography and computed tomography angiography. Patients with extremely insufficient contralateral circulation from the circle of Willis and isolated ventricle were excluded from the study. Indications for CEA were established according to the North American Symptomatic Carotid Endarterectomy Trial (NASCET), Asymptomatic Carotid Surgery Trial (ASCT), and European Carotid Surgery Trial (ECST) criteria.[11-13] All patients were informed about the nature of the study and a written informed consent was obtained. The study protocol was approved by the Istanbul University Faculty of Medicine Ethics Committee (No: 2076, Date: 25/12/2015). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Demographic and clinical characteristics of the patients including age, sex, diabetes mellitus, body mass index, hypercholesterolemia, smoking, hypertension, coronary artery disease, alcohol use, chronic renal failure, preoperative atrial fibrillation, and PAD. The relationship between the ABI and shunt use was assessed.

ABI measurement

Two independent physicians measured the ABI according to the American Heart Association (AHA) recommendations.[5] The ABI measurement was performed using a Doppler device (Dopplex D900, Huntleigh Healthcare Ltd., Wales, UK). Peripheral arterial disease was defined as an ABI of ≤0.90 in either leg, while normal ABI was defined as an ABI of >0.90. The patients with high ABI values (>1.40) with non-compressible leg arteries were excluded from the study.[5]

Surgical procedure

All the operations were performed under regional anesthesia (cervical plexus block). The superior thyroid artery, the external carotid artery, ICA, and the common carotid artery (CCA) were dissected. The neurological examination during the ICA clamping was performed by an anesthesiologist. The consciousness, speech, and motor functions of the contralateral limbs were evaluated. When a pathology occurred in any of these functions, the shunt (Pruitt-Inahara®; LeMaitre Vascular Inc., MA, USA) was inserted. Following arteriotomy, if a shunt was required, a distal shunt was inserted into the ICA and, then, the proximal lumen was deployed into the CCA with a meticulous precaution against air evacuation. The shunt's balloons were, then, inflated and CEA was performed. Once the balloon was deflated, distal and proximal shunts were removed and the clamps were reapplied. The arteriotomy was closed with a Dacron® patch (InterVascular Hemacarotid patch, Datascope, NJ, USA). The incision was closed with a standard procedure following drain insertion.

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 21.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were expressed in mean ± standard deviation, median (min-max) or number and frequency. The normality of data was analyzed using the Kolmogorov-Smirnov test. The independent samples t-test and Mann-Whitney U test were used to examine the mean difference between the two independent groups. Pearson chi-square test, Fisher's exact test, and Yates continuity correction test were used to compare qualitative data. The Spearman rank and Pearson correlation coefficients were used for the correlation analysis. A two-tailed p value of <0.05 was considered statistically significant.

Table 1. Characteristics of patients and risk factors

	Cohort				PAD				
	n	%	Median	Range	n	%	Median	Range	*p*
Patients	56				25				-
Sex									
Male	40	71.4			23	92			0.005
Median age at surgery (years)			66	48-82			72	52-88	-
Preoperative neurologic symptoms	48	85.8			20	80			0.18
Hypertension	40	71.4			20	80			0.32
Diabetes mellitus	24	42.8			10	40			1
Hypercholesterolemia	50	89.2			22	88			1
Coronary artery disease	9	16.1			5	20			0.2
Current smoker	39	20			22	88			0.001
Current alcohol user	19	33.9			11	44			0.31
Contralateral stenosis	6	10.7			1	4			0.34
BMI >30 kg/m^2	12	21.4			3	12			0.38
Chronic renal failure	4	7.1			4	16			0.012

PAD: Peripheral arterial disease; BMI: Body mass index.

RESULTS

Of the patients, 48 (85.8%) were symptomatic and eight (14.2%) were asymptomatic. The CEA procedure was performed within two weeks of acute stroke in all symptomatic patients. Examination of ICA stenosis revealed 50 to 70% ICA stenosis in 10 (17.8%) patients, and 71 to 99% stenosis in 46 (82.1%) patients. Six (10.7%) patients underwent bilateral CEA.

The ABI was measured as ≤0.90 in either leg and PAD was diagnosed in 25 (44.6%) patients. There was a statistically significant correlation between male sex, cigarette smoking, chronic renal failure, and PAD (odds ratio [OR]: 7.75, 95% confidence interval [CI]: 1.7-26.5, p=0.005; OR: 11.5, 95% CI: 2.1-51.1, p=0.001; and OR: 0.45, 95% CI: 0.3-0.5, p=0.012, respectively). The patient characteristics and risk factors are presented in Table 1.

Eleven (19.6%) patients required shunt placement due to neurological deterioration during carotid clamping test. Ten of them (17.8%) had 71 to 99% ICA stenosis, only one had 50 to 70% ICA stenosis, and none of had bilateral carotid lesions. Eight of 11 patients (19.6%) were symptomatic, and three were asymptomatic preoperatively. The mean ABI of 11 (19.6%) patients was 0.8±0.15, while the ABI was less than 0.90 in 10 (90.9%) patients. There was a statistically significant relationship between the perioperative shunt use and PAD (OR: 19.68, 95% CI: 2.3-164.4, p=0.001). The features of patients in whom shunt placement was required are presented in Table 2.

There was no early and late mortality in our study. The first 30-day major stroke rate was 0%; however, minor stroke with mild neurological symptoms was observed in three (5.3%) patients. All patients with minor strokes recovered within the 30-day postoperative period. Local nerve injury related to

Table 2. The features of patients requiring shunt placement

	n	%	Mean±SD
Shunt placement	11		
ICA stenosis ratio			
71- 99%	10	90.9	
50-70%	1	9.1	
Preoperative neurologic symptoms	8	72.7	
The mean ABI			0.8±0.15
ABI <0.9	10	90.9	
ABI >0.9	1	9.1	

ICA: Internal carotid artery; ABI: Ankle-brachial index; SD: Standard deviation.

Table 3. Postoperative early complications

	n	%
Death	0	0
Major neurological complications	0	0
Minor neurological complications	3	5.3
Hypoglossal injury	2	3.5
Myocardial infarction	0	0
Postoperative bleeding	2	3.5
Postoperative hematoma	3	5.3
Wound complications	0	0
Restenosis	0	0

ICA: Internal carotid artery; ABI: Ankle-brachial index; SD: Standard deviation.

the hypoglossal nerve or its branches or the nerves of the platysma occurred in two (3.5%) patients who exhibited tongue deviation and disappearance of nasolabial fold following surgery. The complications are summarized in Table 3.

Carotid artery patch plasty was performed with a Dacron® patch, and a Hemovac drain (Zimmer Inc., IN, USA) was inserted in all patients. Postoperative bleeding was observed in two (3.5%) patients. Minor hematoma was seen in three (5.3%) patients. There was no surgical wound-related complications or wound dehiscence. None of the patients had early or late restenosis.

DISCUSSION

In the present study, we evaluated the possible relationship between the shunt requirement in selective shunt strategy and ABI to identify high-risk patients preoperatively for shunt requirement during CEA under regional anesthesia. The results of this study showed that low ABI was related to a higher rate of shunt requirement in this patient population.

Stroke due to hypoperfusion and/or embolization is one of the most serious complications of CEA. The intraluminal shunt may reduce the hypoperfusion risk by providing blood flow to the distal ICA during ICA clamping. However, shunt placement, itself, is associated with the risk of perioperative stroke caused by embolization.[14] Although routine shunting, selective shunting, or no shunting strategies have been used for many years during CEA, the indications for selective shunt still widely vary.[14] Many monitoring methods guide the decision, as described in previous studies related to general anesthesia. On the other hand, neurological deterioration indicates the use of shunt, when loco-regional anesthesia is applied.[15,16] In our study, we performed all CEA operations under regional anesthesia with a selective shunting strategy. We evaluated the neurological status by qualitative and quantitative examination of the state of consciousness, speech, and motor functions of the contralateral limbs with the carotid clamping test. Neurological status deteriorated in 11 (19.6%) patients during clamping, and we placed shunts between the CCA and ICA.

The ABI is a clinical marker for PAD, and it has been used in the examination of atherosclerosis in patients with stroke.[17] Some authors have shown that decreased ABI is related to severe cerebral ischemic events and may be an independent prognostic factor for cerebral ischemic events.[18,19] In a study in which resting ABI was evaluated, the prevalence of asymptomatic carotid plaque was found to be higher in adults with an ABI of <0.9.[8]

In a prospective study including 102 patients followed for stroke, TIA, and myocardial infarction, Sen et al.[10] reported that 26% had asymptomatic PAD. The authors found that asymptomatic PAD was significantly associated with composite vascular events and stroke. In another study including 176 patients with acute stroke, Tsivgoulis et al.[19] found low ABI values in about one of seven patients without a prior history of symptomatic PAD. Similarly, Jung et al.[20] conducted a study in 231 patients and examined the relationship between the carotid artery stenosis and PAD. Although the severity of ABI was not associated with asymptomatic carotid artery stenosis, cerebral vascular disease showed a statistically significant relationship with asymptomatic carotid stenosis in PAD. These studies have reported a high rate of recurrent vascular events in patients with low ABI.[10,18,19] In the current study, the ABI was measured as ≤0.90 in 25 (44.6%) patients and PAD was diagnosed. The shunt placement was required 10 of these patients due to neurological deterioration during clamping. Our findings showed that 90.9% of the patients who required shunt had an ABI of less than 0.90.

The retrospective and single-center study design are the main limitations of this study. Also, due to the excluded patients with the ABI of ≥1.4, the presented prevalence of the PAD may have been literally miscalculated. Another limitation may be regarded to the small cohort size. Further large-scale, multi-center, prospective studies are needed to obtain more accurate results.

In conclusion, our study results suggest that low ABI during CEA under regional anesthesia is associated with the use of shunts. Preoperative ABI measurement may be suitable for screening patients who may be at a high risk for perioperative vascular events and may be of a high value in predicting perioperative vascular events, particularly during CEA with regional anesthesia. However, given the relevant limitations of the current study, this association needs to be more independently validated in larger patient groups.

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.

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