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Evaluation of external carotid artery flow and thyroid gland functions after carotid endarterectomy

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ABSTRACT

In developed countries, atherosclerosis is the major reason for morbidity and mortality. The external carotid artery is an important collateral in atherosclerotic carotid artery disease. Blind endarterectomy is performed to the external carotid artery during carotid endarterectomy surgery. After the surgery performed by this method, a 5-16% occlusion rate in the external carotid artery was reported in the short and long term. The aim is to show the early pathology on the external carotid artery and its clinical importance after standard carotid endarterectomy. In our study, 30 patients who underwent carotid endarterectomy for carotid artery stenosis were recruited in Istanbul University Cerrahpaşa, Department of Cardiovascular Surgery. Twenty-one patients were male and nine females. The mean age was 63.6 (±9.0). Preoperative duplex ultrasonography was performed in all patients. After discharge, during outpatient control FT3, FT4, and TSH were evaluated with blood tests and flow rates with color duplex. Rate evaluation: <50% stenosis if flow rate is <150 cm/s, 50%-75% stenosis if flow rate is between 150-250 cm/s, and >75% stenosis if flow rate is >250 cm/s. In the duplex examination, we did not detect any significant change in flow rates, external carotid artery flow rates in the preoperative and early postoperative period. However, as expected, a significant reduction in the internal carotid artery flow rates after the operation was recorded. In the analysis of thyroid functions, no significant difference was detected between preoperative and postoperative values. Stenosis, occlusion and dissection can be seen on the external carotid artery after carotid endarterectomy. There are no signs or symptoms due to these lesions. Carotid endarterectomy is a safe procedure for external carotid artery and thyroid superior artery and thyroid gland.

1. Introduction

The most important cause of mortality and morbidity in developed countries is atherosclerosis (Ros, 1993). Atherosclerosis leads to various diseases by creating lesions in blood vessels in different parts of the body. One of these clinical conditions is stroke due to carotid artery involvement. Stroke ranks third among all causes of mortality in the United States, followed by cardiovascular mortality. Today, the incidence of stroke cases is 120-180/100.000 every year (Car et al., 1996). This creates a negative socio-economic effect on society, patient and families. In all treatment protocols, the aim is to prevent cerebral infarction. A transient ischemic attack (TIA) is an alarm that warns us to prevent subsequent stroke or death. Research has mostly focused on this subject for symptomatic or

non-symptomatic carotid artery patients and the cases where surgery is required have been determined as a result of multidisciplinary meetings.

Carotid endarterectomy surgery for stroke prevention gained acceptance rapidly and became the most performed operation. The external carotid artery is an important collateral artery in atherosclerotic carotid artery disease (Aleksi et al., 2009). During carotid endarterectomy, many surgeons perform blinding endarterectomy to the external carotid artery. External carotid artery occlusion has been reported at a rate between 5-16% in the early or late postoperative period with this method (Joseph, 1998). Studies have shown > 50% stenosis in the external carotid artery after carotid endarterectomy in 18% of cases and > 75% stenosis in 10% of cases (Asce et al., 1996). From this point of view, we evaluated the effects of blinding endarterectomy on both the external carotid artery and the superior thyroid artery during carotid endarterectomy and their feeding regions, by evaluating external carotid artery flow parameters (by duplex ultrasonography) and thyroid function tests. Thus, we aimed to investigate the pathology created by standard carotid endarterectomy in the external carotid artery -which is a good collateral artery in the early period- and its clinical significance.

2. Material and methods

This study was conducted on 30 patients who underwent carotid endarterectomy for carotid artery stenosis in Istanbul University Cerrahpaşa Medicine Faculty Department of Cardiovascular Surgery. Ethics committee approval was obtained from the Ethics Commission of Istanbul University Faculty of Medicine (Capa Medicine Faculty) before the study.

Thirty patients were included in the study. Twenty-one patients were male and nine were female. The mean age was 63.6 (± 9.0) years. Twenty five (83.3%) patients were neurologically symptomatic and five (16.6%) were asymptomatic. Of the symptomatic patients 12% had a stroke, one (4%) had amaurosis fugax, one (4%) had syncope and 80% had transient ischemic attacks. When the risk factors were evaluated, 19 (63.3%) patients had hypertension, 11 (33.3%) patients had diabetes mellitus, 20 (66.6%) patients had hyperlipidemia, and 19 (63.3%) patients had a history of tobacco use.

Duplex ultrasonography (100%) was performed in all patients during the preoperative preparation period. Carotid system angiography and carotid system MR angiography were also used for the evaluation of surgical indications. Patients underwent routine carotid endarterectomy (shunts were routinely used and the main carotid artery, the internal carotid artery were

Table 1. Demographic data of patients.

Patient Number	Age	Gender	Symptom	Smoking	DM	HT	History of thyroidal disease	LDL-C mg/dl	HDL-C mg/dl	Total C mg/dl
1	70	M	+	+	-	+	-	98	28	155
2	73	M	+	+	-	+	-	109	34	174
3	55	F	+	+	+	+	-	112	35	209
4	72	F	-	-	+	-	-	164	57	242
5	65	M	+	+	-	+	-	90	33	138
6	70	F	+	-	-	+	-	138	37	203
7	65	M	+	-	+	+	-	143	39	213
8	55	M	+	+	+	+	-	84	33	138
9	73	M	+	-	-	+	-	89	27	139
10	63	F	-	+	+	-	-	186	40	245
11	40	F	-	-	+	-	-	118	23	192
12	59	M	-	+	-	-	+	143	53	211
13	60	M	-	+	-	-	-	205	50	288
14	67	M	+	+	-	+	-	132	29	200
15	64	M	+	-	+	+	-	125	32	180
16	83	M	-	-	-	-	-	85	48	160
17	70	M	-	+	-	-	-	138	34	186
18	59	M	-	+	-	-	-	153	30	199
19	56	F	+	-	-	+	-	122	38	201
20	58	M	-	+	-	-	-	161	41	220
21	58	M	+	-	+	+	-	84	31	156
22	67	F	+	-	+	-	-	82	34	165
23	54	F	+	-	+	+	-	135	47	201
24	57	M	-	+	-	+	-	200	36	268
25	56	M	+	+	+	+	-	98	36	164
26	60	M	+	+	-	+	-	107	50	201
27	62	M	+	+	-	+	-	80	45	147
28	80	M	+	+	-	+	-	159	44	227
29	78	M	+	+	-	+	-	84	39	142
30	60	F	-	+	-	-	-	179	44	245

clamped with the vascular clamp, the external carotid artery and the superior thyroid artery were clamped with the vascular loop) and followed up in the appropriate ward after the procedure. The patients were discharged on average five days postoperatively. The patients were recalled to our polyclinic between 15th and 30th postoperative days for follow-up. Routine blood tests and sT3, sT4, TSH blood tests were performed. Carotid system flow velocities were evaluated by color duplex ultrasonography (USG).

In duplex USG evaluation, peak systolic flow velocities in the main, internal and external carotid arteries were calculated and velocity increases in these vessels were evaluated. Similar to Ascer et al., a flow velocity of <150 cm/sec was evaluated as <50% stenosis, a flow velocity of 150-250 cm/sec was evaluated as 50-75% stenosis, and a flow velocity of > 250 cm/sec was evaluated as > 75% stenosis (Ascer et al., 1996; Table 1, 2).

Statistical analysis

The obtained values were expressed as mean and ± standard deviation values. All data were performed using the SPSS 15.0 statistical software package. The groups were compared by using the Student-t test. p-value <0.05 was considered statistically significant.

3. Results

Duplex USG results revealed that there was no significant change in the external carotid artery flow rates between the preoperative and early postoperative periods in patients who underwent carotid endarterectomy (p=0.184). However, as expected, flow rates of both the main carotid artery and the internal carotid artery were significantly decreased in the postoperative period (p <0.001; Table 3).

Table 3. Comparison of mean peak systolic flow velocities in carotid arteries before and after carotid endarterectomy.

	Preoperative	Postoperative	p value
Main Carotid Artery	105.2 (±30.0) cm/sec (n=30)	82.9 (±18.7) cm/sec (n=30)	< 0.001[x]
Internal Carotid Artery	228.2 (±70.9) cm/sec (n=30)	110.8 (±30.7) cm/sec (n=30)	< 0.001[x]
External Carotid Artery	117.9 (±47.4) cm/sec (n=30)	96.7 (±63.4) cm/sec (n=30)	> 0.984

Blood fT3, fT4 and TSH levels were measured before and after the operation for thyroid gland control. Based on the statistical analysis performed, there was no significant difference between preoperative and postoperative values.

Table 2. Dependent variable parameters.

Patient Number	Preoperative MCA velocity cm/s	Preoperative ECA velocity cm/s	Preoperative ICA velocity cm/s	Preoperative TSH mU/ml	Preoperative fT3 pg/ml	Preoperative fT4 ng/dl
1	103.5	140.7	289	2.57	3.04	1.01
2	132.2	119	275.7	1.2136	2.6	0.92
3	126.2	204	312.1	0.8802	0.56	1.38
4	99.4	106.7	275.8	0.4468	2.44	1.42
5	107.3	92	219.2	1.3815	2.37	1.28
6	132	95	294.7	1.211	2.32	1.19
7	154.3	188	289.4	0.6522	2.7	1.15
8	105.2	112.7	259.2	1.1762	2.75	1.11
9	98.6	123	248.2	1.214	1.72	1.03
10	104.7	134.7	246.4	3.811	2.8	1.01
11	84.3	104	374.2	1.563	2.21	1.34
12	99.4	116	176.5	0.019	2.75	1.41
13	137.2	125.2	199.4	1.401	3.67	1.32
14	104.6	145	154.9	1.1425	2.63	1.19
15	67	166	128.5	0.4182	2.62	1.11
16	117.4	88.5	247.3	2.19	3.5	1.11
17	64.3	109	183.2	0.65	1.7	1.07
18	87.9	60.1	213.7	0.43	3.17	1.2
19	104.5	96.7	154	4.459	3.25	1.27
20	83	167.5	221.4	1.989	2.52	1.06
21	214	0	275.7	1.6342	2.57	1.08
22	78.3	114	215.6	0.981	2.28	1.34
23	85.7	98.9	178.6	2.71	2.71	1.3
24	127	250	402.5	1.49	3.83	1.52
25	105	90.8	208	1.375	3.1	1.2
26	86	154.7	89.4	0.9819	3.12	1.18
27	74.6	104.8	123.9	1.06	2.9	1.26
28	103	70	220	0.9	3	1.09
29	67.5	102.7	148	0.96	2.65	1.56
30	103	58	220	0.74	3.13	1.02

When external carotid artery flow velocities were compared according to the presence of disease risk factors (i.e. hypertension, hyperlipidemia, gender, smoking history and the presence of diabetes), no significant increase was found in flow velocities (p=0.567). Similarly, there was no significant change in thyroid function tests according to risk factors (Table 4, 5). Postoperatively, there was no significant change in thyroid function tests between diabetic and non-diabetic patients (p=0.784; Table 6).

Table 4. Evaluation of thyroid function tests results before and after carotid endarterectomy.

	Preoperative value	Postoperative value	p value
fT3 (pg/ml)	2.7 (±0.6) (n=30)	3.0 (±0.8) (n=30)	> 0.072
fT4 (ng/dl)	1.2 (±0.2) (n=30)	1.2 (±0.2) (n=30)	> 1.00
TSH (mU/ml)	1.4 (±1.0) (n=30)	1.4 (±0.8) (n=30)	> 1.00

Table 5. Evaluation of the effect of diabetes on mean peak systolic flow velocity in the external cartois artery after carotid endarterectomy.

	DM + (11 patients)	DM – (19 patients)
Preop ECA peak systolic flow velocity (cm/sec)	120.0 ± 55.0	116.7 ± 44.0
Postop ECA peao systolic flow velocity (cm/sec)	128.4 ± 91.2	78.4 ± 29.8
P value	> 0.784	> 0.996

Table 6. Evaluation of the effect of diabetes on mean free T3, free T4 and TSH values after carotid endarterectomy.

	DM + (11 patients)		DM – (19 patients)		p value
	preop	postop	preop	postop	
TSH (mU/ml)	1.4 ± 1.0	1.5 ± 1.0	1.4 ± 1.0	1.3 ± 0.7	> 1.02
fT3 (pg/ml)	2.4 ± 0.7	2.8 ± 0.9	2.8 ± 0.6	3.1 ± 0.7	> 1.08
fT4 (ng/dl)	1.2 ± 0.1	1.2 ± 0.2	1.2 ± 0.2	1.2 ± 0.2	> 1.00

One (3.3%) of the patients, flow velocity in the external carotid artery could not be detected by Doppler ultrasonography on the 15th postoperative day (occlusion). Patient had no significant complaints and there were no physical examination findings. Therefore, it was decided to continue the patient's treatment without any changes and the patient is being followed clinically.

In one patient (3.3%), although the external carotid artery flow velocity was 80.7 cm/sec, Doppler ultrasonography showed dissected vessel wall and flap. 65-year-old female patient had no risk factors other than hypertension. Dissection was detected during routine follow-up and the patient was taken to the outpatient clinic follow-up due to the lack of complaints or clinical symptoms (Fig. 1).

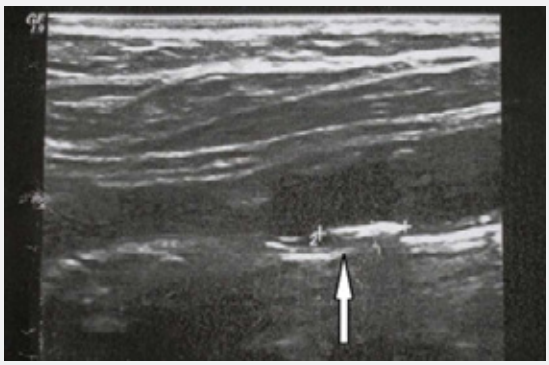

Fig. 1. Flap in the external carotid artery after the operation (arrow).

In addition, flow velocity above 250 cm/sec was detected in two (6.6%) patients. This rate is compatible with >75% stenosis. Less than 50% stenosis was detected in the rest of the patients (86.6%) according to the peak systolic velocity of the external carotid artery. The mean systolic velocity of the external carotid artery after carotid endarterectomy was 96.7 ± 63.4 cm/sec.

4. Discussion

In carotid endarterectomy, endarterectomy for the external carotid and superior thyroid arteries is performed blindly. Pathologies such as restenosis, occlusion and dissection may develop in these arteries due to blinding endarterectomy for the external carotid artery performed as a routine surgical method. Cerebrovascular disease caused by embolism in the retrograde internal carotid artery due to thrombosis of the external carotid artery may also be seen (Ascer et al., 1996). In our series, two (6.6%) patients had >75% stenosis, one patient (3.3%) had occlusion, and one patient (3.3%) had dissection after carotid endarterectomy according to peak systolic flow velocities and color Doppler ultrasonography. In total, three (10%) patients developed >50% stenosis. The rate of non-severe external carotid artery stenosis was 86.6% with 26 patients.

In a study by Archie et al. 10% (±2) of 313 patients undergoing carotid endarterectomy operation had severe stenosis or >75% stenosis in the external carotid artery postoperatively. The rate of patients with <50% external carotid artery stenosis in the early period was 74% (±6.9) (Joseph, 1998). Ascer et al. also detected <50% early postoperative stenosis in 93 (82%) out of 116 patients who underwent blinding external carotid artery endarterectomy. 50-74% stenosis in the external carotid artery was detected in 11 (10%) patients, whereas >75% stenosis was detected in nine (8%) patients. Full occlusion was not observed in any patient after the operation (Ascer et al., 1996). In their 2009 study, Aleksic et al. measured flow volume in carotid arteries by Doppler ultrasonography. According to the

results of this study, the volume in the external carotid artery has decreased by 4% in the early postoperative period (Aleksic et al., 2009).

Although no complications related to the superior thyroid artery have been reported in the literature, we wanted to evaluate the thyroid gland using thyroid function tests. Based on the results of our study, it was seen that there was no significant change in thyroid function tests. When the patients were examined according to risk factors, no significant results were found in terms of thyroid function tests. There are studies in which the superior thyroid artery is used as a graft for the patch. In a study by Jenkins et al., an ipsilateral superior thyroid artery was used as the patch. The authors reported that using the superior thyroid artery as a patch did not create any complications on thyroid gland function (Jenkins et al., 1997).

The optimal method of protecting the external carotid artery during carotid endarterectomy is unclear. In the study comparing the blinding and eversion methods performed by Archie et al., external carotid artery restenosis rates were similar (Joseph, 1998). The importance of the external carotid artery during carotid endarterectomy does not only apply to the area perfused by the external carotid artery. At the same time, the external carotid artery may be a source of embolism that may affect the internal carotid artery during and after the operation (Ascer et al., 1996). Therefore, the external carotid artery should be carefully protected during and after the operation. Moore reported three cerebrovascular embolism cases that developed in an antegrade route from the internal carotid artery due to the flap forming in the external carotid artery following carotid endarterectomy, and progressed in a retrograde route (Moore et al., 1990). Therefore, complications and disease may occur if the external carotid artery is not maintained during the operation and insufficient endarterectomy is performed.

In the study of Ascer et al., the rate of patients with >75% stenosis in both external and internal carotid arteries after carotid endarterectomy was found to be 8%. Approximately 80% of the patients had stenosis in the external carotid artery, though less than 50%. The point to be taken here is that in order for a postoperative ischemic event related to the internal carotid artery to develop, the external carotid artery may need to be occluded. Severe stenosis or occlusion of the external carotid artery does not cause significant ischemic clinical problems and is usually a benign disease (Ascer et al., 1996). Ascer et al. performed endarterectomy by transecting the atherothrombosis in the external carotid artery orifice in order to avoid blinding endarterectomy to the external carotid artery, and argued that this technique did not cause postoperative or perioperative neurological complications and severe stenosis of the external carotid artery (Ascer et al., 1996). In this study, the rate of severe (> 75%) stenosis in the external carotid artery was found to be 8% in the early postoperative period. In the study of Archie et al., blinding endarterectomy and eversion methods were compared. Here, longitudinal arteriotomy was performed after transecting the external carotid artery and complete plaque removal was achieved. Postoperative severe external carotid artery stenosis rate was found to be 10% (Joseph, 1998). These two studies reported highly similar results.

As Aleksic emphasized in his study, for the better results, performing the controls of the arteries with caution and as less traumatic as possible, considering the traumatic effect of the clamps and even the vascular loops used, exploration of the external carotid artery with its branches if necessary, and extending the arteriotomy to the appropriate site are acceptable options (Aleksic et al., 2009). In other studies, external carotid artery thrombosis, either symptomatic or asymptomatic, is reported in the literature in varying rates between 5% and 16% (Ascer et al., 1996). Stenosis or occlusion of the external carotid artery following carotid endarterectomy may not cause significant clinical problems and many of these may not require intervention. However, the external carotid artery should still be preserved during surgery because of its collateral importance, especially in patients with lesions in the contralateral carotid artery. The superiority of the methods performed for this purpose such as eversion endarterectomy and shunt application to the external carotid artery over standard carotid endarterectomy could not be demonstrated.

In a study in which shunt application was performed to the external carotid artery during carotid endarterectomy, it was stated that shunt application to the external carotid artery did not create a significant change in surgical technique and did not change the clamp time. In this study, shunt was applied to the external carotid artery at the time of a neurological event in patients operated under locoregional anesthesia and routine shunt application was not performed. The importance of the external carotid artery as a collateral vessel was investigated (Belardi et al., 2001). However, as a result, if a shunt was to be applied to the external carotid artery, proximal branches were considered and it was decided to apply the shunt up to the first 3 cm of the artery and it was concluded that shunt application to the external carotid artery did not have significant effects in terms of the operation (Belardi et al., 2001). This study has a number of limitations worth noting. First, we conducted a retrospective study. Second, the number of patients, which were included in our study, may seem relatively small compared to other studies. Third, it's a single-center design. Further prospective randomized trials with large volumes are needed to compare evaluation of external carotid artery flow and

thyroid gland functions after carotid endarterectomy.

Postoperative external carotid artery stenosis or occlusion is roughly attributed to incomplete endarterectomy or the flap remaining in the lumen. During the operation, endarterectomy on the external carotid artery with an open technique (non-blinding endarterectomy) should be performed by visually observing the most distal part of the thrombotic plaque and not leaving any residual flap as in the internal carotid artery. However, in this way, factors such as prolonged operation time, greater dissection and increased anastomosis length will come into play. In order to make a healthy and more definitive evaluation, we need to perform further external carotid endarterectomy operations and evaluate their results. Carotid endarterectomy is a safe procedure for external carotid artery and thyroid superior artery and thyroid gland.

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