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Institutional report - Vascular general

Complete transposition of carotid bifurcation: can it be an additional risk factor of injury to the cranial nerves during carotid endarterectomy?

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Abstract

The internal carotid artery (ICA) usually, lies posterolaterally to the external carotid artery (ECA). Sometimes a complete carotid transposition can occur, with the ECA in a lateral position and the ICA on the medial side can occur. Our study evaluated the significance and impact that this anomaly may have on cranial nerve injuries. From January 2008 to November 2010, 296 patients underwent 360 consecutive primary carotid endarterectomy (CEA) procedures. During carotid isolation, we detected an unexpected lateral position of the ECA in 11 cases (3.6%). χ^2 analysis and the Student's *t*-test were used to compare the incidence of cranial nerve injuries between the 11 patients with the lateral ECA who underwent CEA (group A) and 11 randomized patients with a normal bifurcation (group B). Statistical significance was inferred at $\chi^2>3.84$ and $P<0.05$. A statistical difference in the incidence of superior laryngeal nerve paralysis was detected between groups A and B (18.1%, 2/11 in group A vs. 0%, 0/11 in group B; $\chi^2>3.84$; $P<0.05$). No differences in incidence of injury were detected for the other cranial nerves. A very meticulous mobilization of the ECA and ICA is needed to perform CEA, but superior laryngeal nerve injury can occur despite the use of a safe and meticulous surgical technique.

Keywords: Carotid bifurcation anomalies; Carotid endarterectomy; Cranial nerve injury

1. Introduction

Anatomy texts document that the carotid bifurcation is generally located between C3 and C4, although individual variations are well reported, with the internal carotid artery (ICA) lying behind or posterolateral to the external carotid artery (ECA) in 88% of cases [1, 2]. Vascular anomalies including aberrant branching patterns or ICA/ECA transposition may have important surgical implications, especially in terms of the incidence of cranial nerve damage. The aim of our study was to evaluate the impact of a lateral position of the ECA on cranial nerves injuries.

2. Methods

From January 2008 to December 2010, 296 patients (mean age 70±12 years) underwent 360 consecutive primary carotid endarterectomy (CEA) procedures; in all cases, a short longitudinal incision was made along the sternocleidomastoid muscle. Of the patients, 208 were male (57.7%), and 216 (60%) reported prior neurological symptoms. Patients' demographic data and preoperative planning details are presented in Table 1.

All patients were submitted to a standard preoperative evaluation by a neurologist and otorhinolaryngology (ENT) specialist. Postoperative investigation included re-evaluation by the neurologist and the ENT specialist one or two days after the operation (with fiberoptic laryngoscopy applied only in cases of vocal cord dysfunction), at day three or four, and then at the third month.

During carotid isolation, we detected an unexpected lateral position of the ECA (Fig. 1) in 11 patients (3.6%). After ligating the crossing arterial branches, superior thyroid artery generally, and lingual and facial arteries sometimes, the hypoglossal and vagus nerves were identified, and circumferential mobilization of the ECA and ICA was attempted. In all cases, common carotid artery (CCA) clamping was performed during medialization of the ECA and circumferential dissection of the bifurcation in order to avoid microembolic complications.

Standard CEA with Dacron patch angioplasty (Maquet Cardiovascular, Datascope, La Ciotat, France) was performed in almost all patients (322, 89.2%). Eversion endarterectomy was carried out on the kinked/coiled ICA in 38 cases (10.8%). As we regularly use general anesthesia with remifentanil to conserve consciousness so that patients are

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Table 1. Demographic data

	n	%
Male	208	57.7
Female	152	42.3
Asymptomatic	144	40.0
Symptomatic	216	60.0
Diabetes mellitus	245	68.1
Coronary artery disease	231	64.1
Peripheral arterial disease	94	26.1
Hypercholesterolemia	125	34.7
Hypertriglyceridemia	100	27.7
Stenosis		
60–70%	30	8.3
70–90%	252	70.0
>90%	63	17.5
Pseudo-occlusion	15	4.1
Contralateral occlusion	54	15.0

always awake and alert [3], a shunt deployment policy was used (48 patients, 13.3%). No particular problems were encountered in achieving safe distal control of the ICA after medialization of the ECA.

Statistical analysis was performed by using χ^2 analysis for categorical variables and the Student's *t*-test for numeric variables (SPSS software 13.0 version; SPSS Inc, Chicago, USA) to compare the surgical results for the 11 lateral ECA patients (group A) with those of the 11 randomized patients with a normal bifurcation (group B). The demographic patient data for the two groups are reported in Table 2. In group B, patients were allocated to a sequence of random numbers in line with their place on the appointment list. Statistical significance was inferred at χ^2>3.84 and P<0.05.

3. Results

3.1. Operative procedures

No statistical differences in carotid clamping and total operative time were observed. No technical difficulty was detected in performing ICA clamping after medialization of the ECA and endarterectomy with patch closure. No patient in either group needed shunt deployment or eversion endarterectomy.

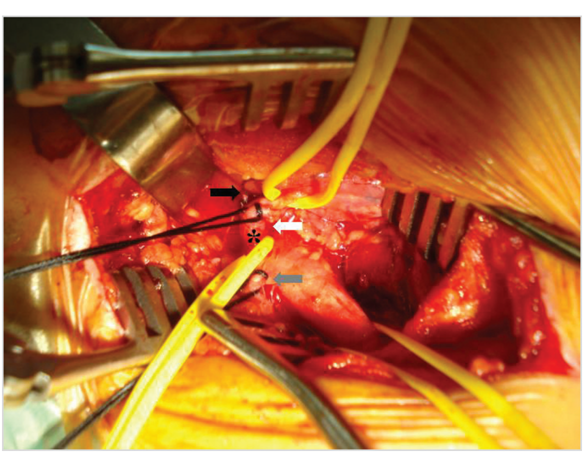

Fig. 1. Intraoperative view showing complete transposition of the external carotid artery (*), which lies in a posterolateral position anterior to the internal carotid artery (white arrow). The superior thyroid artery (grey arrow) and hypoglossal nerve (black arrow) were isolated.

3.2. Complications

No death, neurological complications or postoperative hematoma were reported either group. A statistical difference was detected in the incidence of superior laryngeal nerve (SLN) paralysis between the two groups (18.1%, 2/11 in group A vs. 0% 0/11, in group B; χ^2>3.84; P<0.05). No differences were observed regarding the other cranial nerves in terms of incidence of injury (Table 3).

4. Discussion

Epidemiological evaluation of the lateral position of the ECA is still controversial. Indeed, despite the fact that few cases have been reported in the medical literature, angiographic and ultrasound examinations appear to document a significant incidence of this anomaly, ranging in incidence between 4% and 12%, and reaching 16% in elderly patients [4, 5]. This is due to an absence of stringent criteria for defining the degree of rotation of the carotid bifurcation required to consider the ECA as lying lateral to the ICA. Thus, the definition of a laterally positioned ECA (LECA) is often operator-dependent and subject to bias, and the real incidence remains elusive. In our experience, the criteria proposed for defining a LECA are that the superior thyroid artery and lingual and facial branches should cross and cover the ICA, with the ECA lying posterior or posterolaterally to the ICA (Fig. 1).

The position of the LECA is generally the result of excessive mediolateral migration of the ECA during embryogenesis, but age-related elongation and tortuosity of the carotid arteries due to atherosclerosis may be a secondary cause [6].

The increase in incidence of cranial nerve injuries in the presence of a LECA during CEA is still under debate, and some authors do not show a positive correlation with cranial nerve injuries [7]. Instead, in our experience, we note a statistically significant incidence of dysfunction of the external branch of the SLN (EBSLN).

The SLN originates from the middle of the nodose ganglion of the vagus nerve. The common trunk bifurcates close to the ICA into a motor EBSLN and an internal sensory and autonomic (IBSLN) branch that begins posteriorly and medially to the ICA and then to the ECA. The IBSLN takes a higher route than the EBSLN, descending near to the origin of the superior thyroid artery (Fig. 2) [8, 9]. The EBSLN is generally injured during circumferential dissection and mobilization of the ECA and superior thyroid artery during CEA.

The SLN and its branches are often not easily visible, showing some anatomical variations in terms of route or branching patterns [10]. In cases of an LECA, each branch, especially the EBSLN, runs posterior to the ICA and then the ECA.

Thus, a medial derotation of the carotid bifurcation to perform safe CEA in one study required an extensive and careful circumferential dissection of these vessels, inadvertently leading to IBSLN/EBSLN injury [11]. The lesion involving the EBSLN was clinically manifested by hoarseness, a breathy voice, increased throat clearing, vocal fatigue and diminished vocal frequency range. On fiberoptic

Table 2. Demographic data related to the groups examined

	Group A (11)		Group B (11)		Total (22)			
	n	%	*n*	%	*n*	%	χ^2	*P*-value
Male	6	54.5	7	63.6	13	59.1	0.61	>0.1
Female	5	45.4	4	36.3	9	40.9	0.61	>0.1
Asymptomatic	3	27.2	5	45.4	8	36.3	0.02	>0.1
Symptomatic	8	72.7	6	54.5	14	63.4	0.02	>0.1
Diabetes mellitus	8	72.7	7	63.6	15	68.1	0.14	>0.1
Coronary artery disease	6	54.5	6	54.5	12	54.5	0.12	>0.9
Peripheral arterial disease	2	28.1	2	28.1	4	18.1	0.01	>0.1
Hypercholesterolemia	4	36.3	5	45.4	9	40.9	0.53	>0.1
Hypertriglyceridemia	3	27.2	6	54.5	9	40.9	0.12	>0.9
Stenosis								
60–70%	1	9.1	2	28.1	3	13.6	0.53	>0.1
70–90%	8	72.7	7	63.6	15	68.1	0.14	>0.9
>90%	1	9.1	2	28.1	3	13.6	0.16	>0.9
Pseudo-occlusion	1	9.1	–	–	1	4.5	NS	NS
Contralateral occlusion	–	–	–	–	–	–	–	–

NS, not significant.

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laryngoscopy examination, ipsilateral paralysis of the crico-thyroid muscle with a shift of the supraglottis to the contralateral side and shortening of the contralateral true vocal cord was detected. In our experience, we never identified a lesion of the IBSLN. Indeed, at fiberoptic laryngoscopy, no cases with a loss of touch sensation on the aryepiglottic fold of the affected side were observed.

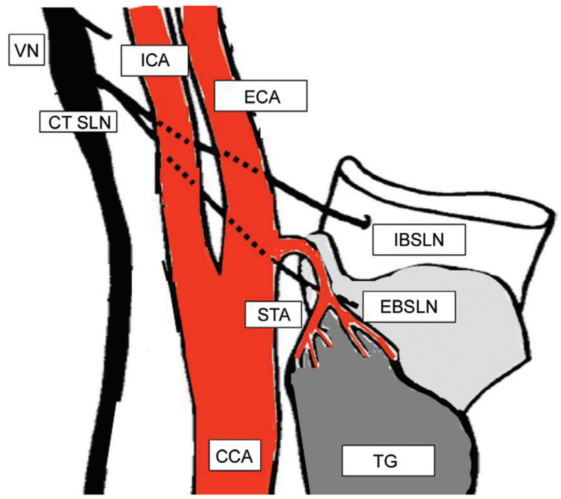

Fig. 2. Topographical anatomy of the superior laryngeal nerve and its branches. CCA, common carotid artery; CT SLN, common trunk of the superior laryngeal nerve; EBSLN, external branch of the superior laryngeal nerve; ECA, external carotid artery; IBSLN, internal branch of the superior laryngeal nerve; ICA, internal carotid artery; STA, superior thyroid artery; T, thyroid gland; VN, vagus nerve.

In according with many reports, no differences were noted between the two groups regarding the incidence of hypoglossal nerve injuries. Indeed, the hypoglossal nerve, which generally passes lateral to the ECA, does not require extensive mobilization. In no case was section of the hypoglossal ansa carried out. Despite some authors advocating a routine transection to reduce the stretch on the hypoglossal nerve, in our opinion a nerve-sparing approach is justified by the evidence of nerve route anomalies, especially of the recurrent laryngeal nerve [12]. No positive correlation between a lateral position of the ECA and the presence of a non-recurrent inferior laryngeal nerve was reported in our series or in the literature [13].

Despite an accurate preoperative work-up with color-coded duplex ultrasounds, we observed real difficulty on ultrasound scanning in making a precise quantification of the degree of transposition of the carotid bifurcation [14], often making it difficult to evaluate the impact on surgical technique. Indeed, in the presence of a suspected anomalous route of the ECA and ICA on ultrasound scanning, it might be preferable to undertake a computed tomographic angiography [15] or magnetic resonance imaging scan to achieve more accurate preoperative planning.

Table 3. Results and distribution of nerve injuries between the groups

	Group A (11)		Group B (11)		Total (22)			
	Patients	%	Patients	%	Patients	%	χ^2	*P*-value
Superior laryngeal nerve	2/11	18.1%	0/11	0	2/22	9.1	3.84	<0.05
Recurrent laryngeal nerve	–	–	–	–	–	–	–	NS
Hypoglossal nerve	–	–	–	–	–	–	–	NS
Vagus nerve	–	–	–	–	–	–	–	NS
Glossopharyngeal nerve	–	–	–	–	–	–	–	NS
Accessory nerve	–	–	–	–	–	–	–	NS
Major stroke	–	–	–	–	–	–	–	NS
Minor stroke	–	–	–	–	–	–	–	NS
Death	–	–	–	–	–	–	–	NS

NS, not significant.

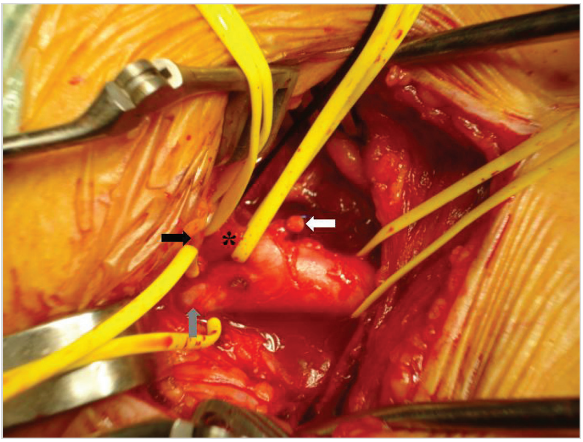

Fig. 3. Intraoperative view. After section of the superior thyroid artery (white arrow) and circumferential dissection of the external carotid artery (*), the internal carotid artery (grey arrow) and the bifurcation were normally placed. The vagus nerve was identified but not isolated. Hypoglossal nerve was mobilized and retracted upwards (black arrow).

Regarding the technical note in cases of LECA, all the crossing vascular branches must be ligated (Fig. 3). After identifying the hypoglossal and vagal nerves, a careful dissection of the ECA was carried out. The vagus nerve should be identified, avoiding its circumferential isolation, and then the ICA was mobilized with carotid bifurcation. During this stage, we prefer CCA clamping to avoid microembolization due to bulb isolation.

5. Conclusions

A lateral position of the ECA does not seem to be uncommon, especially in the elderly population. Very meticulous mobilization of the ECA and ICA is needed to perform CEA, but injury of the SLN can occur despite use of a safe and meticulous surgical technique, especially if a wide isolation and derotation are required.

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