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Surgical approach to carotid sinus syndrome and carotid body tumor

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**Introduction**

In a large cohort of patients older than 40 years with suspected reflex syncope, carotid sinus massage (CSM) was diagnostic for carotid sinus syndrome (CSS) in 12% [1]. When CSM reproduces the patient’s symptoms with dominant cardioinhibition, dual-chamber pacing is recommended as a class IIA indication [2]. Nevertheless, pacing is inefficient in vasodepressive and has limited efficacy in the mixed forms of CSS or in terms of the association of cardioinhibitory CSS with positive hypotensive phenotype at tilt testing [3]. That is why the established role for surgery in CSS [4,5] should be further emphasized.

In this paper, our approach to surgery on carotid artery-related structures in CSS and patients with carotid body tumor (CBT); an early outcome of extensive carotid artery denervation, and safety issues associated with autonomic cardiovascular control are presented.

**Methods**

**Study population**

The following groups of patients were diagnosed and surgically treated: nine patients with CSS (mean age-71.4 years), three patients with both CSS and CBTs (mean age-47.7 years), and sixteen patients with a solitary CBT (mean age-43.6 years). Surgical procedures for CSS and/ or CBTs were performed between 2010 and 2019 in the Department of Vascular Surgery of the Military Medical Institute, Warsaw, Poland.

All patients provided informed consent prior to surgery. The research follows the requirements for retrospective studies of the local ethical board.

The evaluation of patients with syncope included: physical examination, 12-lead ECG, 24-hour Holter ECG monitoring, echocardiography and tilt-table testing. The CSS diagnosis was finally confirmed by CSM performed according to the recommendations [2,6]. In patients with CBTs, a CT scan and digital subtraction angiography confirmed a pathological mass at the carotid bifurcation (Figure S1).
Statistical analysis

Statistical analysis was performed using Statistica v.13.3 software. Non-parametric continuous data are shown as median and interquartile range and compared using Mann–Whitney U test. Categorical data are shown as percentages and compared using chi² or Fisher’s exact tests as appropriate.

Results and Discussion

Clinical data are presented in Table 1.

All patients from the CSS “alone”, and from CSS with CBTs groups had syncope without any obvious triggering factors, and had experienced more or less violent traumas when losing consciousness. The indication for surgery was fainting spells, which increased in frequency up to several times a day. CBT patients were referred to surgery for oncologic reasons [7].

Surgical technique – own approach

During surgery, the ICA, the external carotid artery (ECA), the common carotid artery (CCA), the jugular vein, the vagus, hypoglossal nerves and the sympathetic trunk were preserved. In most cases, it was not necessary to cut across the carotid arteries. Only in two patients was the replacement of the ICA required due to continuous tumor involvement (the Shamblin type III). A six mm prosthetic Dacron graft was used as a conduit between the CCA and distal section of the ICA. Circulation via the ECA was not restored.

Carotid denervation was performed with a minimum radius of 3 cm from the carotid bifurcation, meaning 3 cm below and distal dissection of the CCA, the ICA and the ECA from surrounding tissues (Figure S1). There were much larger segments of surgical exposure than those described in the literature. When combined with chemodectoma excision, this margin of carotid artery preparation was inherent in the surgical procedure. We did not preoperatively embolize the CBT arteries routinely [8].
Minor complications included wound hematoma (n=2) and neuropraxia of the marginal mandibular branch (n=4). In no patients was a significant alteration in systolic/diastolic blood pressure or heart rate observed. Suture removal took place two weeks after the surgery, and on the 30th day the ultrasonography of the carotid arteries was performed. The patients were completely free from their previous symptoms. The last surgical consultation was performed one year after the surgery. Despite lack of a direct evidence, no concerning information from the family doctors/local cardiologists and the patients themselves may suggest that the outcomes were acceptable and also long-lasting.

For many patients with CSS, vast adventitial stripping of the carotid arteries may be a reasonable alternative to pacemaker implantation or the therapeutic method of choice, since the vast majority of CSS patients probably present with a mixed form with a significant vasodepressor component [4]. In our series, all CSS patients, who received more extensive unilateral carotid artery denervation than demonstrated in other studies [4], in the 30-day period after surgery were symptom free and, importantly, showed no clinically relevant impairment of cardiovascular autonomic control. In the Toorop’s study [4], during such a period after carotid denervation by adventitial stripping of the ICA in the CSS patients, 93% of subjects were symptom free. The retrospective analysis and additional examination of the surviving patients from the Toorop’s study suggested also the long-term efficacy of the surgery with the lack of a baroreflex failure [9].

CSS is predominantly diagnosed in elderly people, and is associated with diabetes, hypertension and atherosclerosis [4,10], i.e., conditions accompanied by structural modification of the carotid arterial adventitia and carotid extra-media thickness [11], which in turn might be involved causally in CSS. In our study, patients with “CSS alone” were between 59 and 80 years of age, whereas two of the three subjects with both CSS and CBTs were significantly younger, and matched the age range of patients with “CBT alone”. This may
suggest some distinctive pathophysiological features, i.e., the mechanical irritation of respective autonomic structures by a tumor, especially that the two patients had the Shamblin type III tumor (Table 1). Surgical removal of a tumor not only definitely eliminates CSS symptoms, but also the need for pacemaker, which could be explanted [12], probably as in case of spontaneous healing of the carotid artery dissection responsible for transient cardioinhibitory CSS [13].

In conclusion, vast adventitial stripping of the carotid arteries in CSS should be validated as an alternative to pacemaker implantation in cardioinhibitory CSS or as a therapeutic option for the clinically relevant mixed and vasodepressor forms of CSS. When necessary, it is feasible to operate simultaneously on patients with symptoms of both CSS and CBTs. Although vast unilateral carotid denervation and CBTs excision interfere with autonomic nervous system integrity, they did not trigger clinically relevant impairment of cardiovascular autonomic control.
References:


Table 1. Clinical characteristics of the study population according to the diagnosis determining the type of surgery.

<table>
<thead>
<tr>
<th>Variable</th>
<th>CSS, n=9</th>
<th>CSS with CBT, n=3</th>
<th>CBT, n=16</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>M/ F</td>
<td>3/ 6</td>
<td>1/ 2</td>
<td>5/ 11</td>
<td>0.99</td>
</tr>
<tr>
<td>Median (age) [IQR], years</td>
<td>71 [67 – 78]</td>
<td>55 [22 - 66] *</td>
<td>42.5 [40 – 47] †</td>
<td>0.0001</td>
</tr>
<tr>
<td>History of smoking, n/ %</td>
<td>6 (66.7)</td>
<td>1 (33.3) a</td>
<td>11 (68.8)</td>
<td>0.5</td>
</tr>
<tr>
<td>Diabetes mellitus, n/ %</td>
<td>4 (44.4)</td>
<td>1 (33.3) a</td>
<td>2 (12.5)</td>
<td>0.14</td>
</tr>
<tr>
<td>Hypertension, n/ %</td>
<td>5 (55.5)</td>
<td>2 (66.6) a</td>
<td>7 (43.7)</td>
<td>0.7</td>
</tr>
<tr>
<td>History of AMI, n/ %</td>
<td>2 (22.2)</td>
<td>1 (33.3) a</td>
<td>2 (12.5)</td>
<td>0.63</td>
</tr>
<tr>
<td>History of stroke, n/ %</td>
<td>2 (22.2)</td>
<td>1 (33.3) a</td>
<td>0 (0)</td>
<td>0.1</td>
</tr>
<tr>
<td>Ci/ Vd/ Mx, n</td>
<td>4/ 5/ 0</td>
<td>2/ 1 /0</td>
<td>n. a.</td>
<td>0.5</td>
</tr>
<tr>
<td>Shamblin classification</td>
<td>n. a.</td>
<td>0/ 1/ 2 †</td>
<td>7/ 9/ 0</td>
<td>0.02</td>
</tr>
<tr>
<td>Type I/ II/ III, n</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left-sided surgery, n/ %</td>
<td>6 (66.7)</td>
<td>3 (100)</td>
<td>11 (68.8)</td>
<td>0.51</td>
</tr>
</tbody>
</table>

AMI = acute myocardial infarction; CBT = carotid body tumor; Ci = cardioinhibitory type of CSS at CSM; CSM = carotid sinus massage; CSS = carotid sinus syndrome; F = female; IQR

1 The criteria for diagnosing the CSS (“method of symptoms”) at CSM:
= interquartile range; M = male; Mx = mixed\textsuperscript{1} type of CSS at CSM; n. a. = non applicable; Vd = vasodepressive\textsuperscript{1} type of CSS at CSM;

* the difference between the CSS with CBT vs. CSS “alone” groups compared using Mann – Whitney U test ($P = 0.016$); the respective $P$ value shown in Table 1 results from the nonparametric Kruskal-Wallis ANOVA.

† the difference between the CBT vs. the CSS “alone” groups compared using Mann – Whitney U test ($P < 0.0001$); the respective $P$ value shown in Table 1 results from the nonparametric Kruskal-Wallis ANOVA.

‡ the difference between the CSS with CBT vs. the CBT “alone” groups compared using Fisher’s exact tests ($P$ value shown in Table 1).

\textsuperscript{a} clinical data concerning the 66-year old patient with both CSS and CBT.

<table>
<thead>
<tr>
<th>CSS type</th>
<th>Cardioinhibitory</th>
<th>Mixed</th>
<th>Vasodepressor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnostic criteria</td>
<td>Asystole $&gt;_3$ s</td>
<td>Asystole $&gt;_3$ s and SBP drop $&gt;50$ mmHg\textsuperscript{b}</td>
<td>SBP drop of $&gt;50$ mmHg</td>
</tr>
</tbody>
</table>

\textsuperscript{b} after intravenous administration of 1 mg atropine