Paragangliomas, also known as chemodectomas or carotid body tumors, are rare neuroendocrine tumors. They represent about 0.03% of all neoplasms and appear more frequently in women than men (1.9:1) [1–3]. About 50% of paragangliomas develop in the head and neck region, of which approximately 50% originate from the carotid body [4]. The carotid body was first described by von Haller in 1743 [5]. It mainly regulates pH, pO₂ and pCO₂ levels in the blood by registering changes in those parameters and transmitting them through the glossopharyngeal nerve.
to the reticular formation [2, 6]. It has been reported that 6% of carotid paragangliomas are malignan
[3, 4]. Malignancy is defined by presence of metastases in regional lymph nodes or dis-
tant sites, mainly in the lungs or bones [2, 7–9]. About 30% of paragangliomas are caused by mu-
tations in succinate dehydrogenase (SDH) sub-
unit genes: SDHD (the subunit D gene), SDHB (the subunit B gene), SDHC (the subunit C gene) or SDHAF (the subunit A gene) [10]. SDH muta-
tions are associated with familial paragangliomas,
previous pheochromocytomas, or the presence of
multifocal paragangliomas such as tumors in the
neck [11, 12]. In SDH mutation carriers, who are
predominantly male, the onset of paraganglioma
often occurs before 40 years of age [11, 12]. Tu-
mors related to gene mutations have a high risk
of malignancy. The malignancy rate is the highest
in the SDHB mutations, reaching about 38% [12].

Bilateral carotid paragangliomas account for
5% of all cases. Familial tumors occur in 33% of the
cases, and in those patients multifocal localization
is as high as 80% [13]. The tumors are usually lo-
cated at the bifurcation of the common carotid ar-
tery. The first symptoms are painless, mobile, slow
growing tumors which may pulsate. In cases where
nerve XII and the common carotid artery are infil-
trated, hearing loss and tinnitus appear [8, 9]. Oth-
er symptoms related to tumor compression on cran-
ial nerves IX, X, XI, and XII include hoarseness,
ear pain, difficulty swallowing and Horner’s syn-
drome. Vascular phenomena such as pulsations or
murmurs, and symptoms of common carotid ar-
tery compression resulting in cerebral ischemia
or carotid sinus syndrome with bradycardia and
syncope may also occur [2, 6, 8, 9, 14–16]. Rarely,
hoarseness appears as the first symptom. This is
caused by vocal cord paralysis, as paragangliomas
tend to spread to the superior and recurrent laryn-
geal nerve [2, 6, 9, 15].

Differential diagnoses of head and neck para-
gangliomas include enlarged neck lymph nodes, lat-
eral neck cysts, pathologic changes in the parotid
gland and carotid aneurysm [2, 6]. Carotid body
hyperplasia must also be considered; it can develop
due to chronic hypoxia and is described mainly in
patients living at high altitudes [6, 9]. Diagnoses of
paragangliomas are based on imaging. The exami-
nation of choice is computed tomography angiog-
raphy. If a diagnosis of paraganglioma is suspected,
a biopsy is contraindicated due to the high risk of
hemorrhage [9, 15]. The recommended treatment
is surgical intervention or stereotactic radiosur-
gery. The choice of treatment modality depends on
many factors: the location of the tumor, the stage
of the disease, the patient’s age and health condition,
as well as his or her preferences.

Material and Methods

The study group was made up of patients with
carotid paragangliomas who were treated at Wro-
claw Medical University’s Department of Otolaryn-
gology, Head and Neck Surgery and Department of
General, Vascular and Transplant Surgery, and at
the Surgery Department of the 4th Military Teach-
ing Hospital in Wroclaw (Poland) between 1985
and 2014. During this period of time, 47 patients
were operated on and 49 paragangliomas were di-
agnosed (including 2 cases of bilateral carotid para-
ganglioma). The patients’ medical data were ret-
respectively analyzed. The study group included
28 men (60%) and 19 women (40%). Bilateral tu-
mor occurred in 2 patients: 1 woman and 1 man
(4%). The average age of the patients was 45 years
(ranging from 34 to 56). All the patients denied any
neoplastic disease in family members. All the pa-
tients presented neck tumors (100%). Other com-
plaints were as follows: hoarseness in 14 patients
(30%), swallowing difficulties in 10 (21%), discom-
fort in the neck area in 10 (21%) and tinnitus in
13 (28%). All the patients underwent duplex ultra-
sound examinations, and in 20 (43%) computed to-
mography angiography of the neck was also per-
formed. In 36 patients (77%) the diagnosis was
made correctly before surgery, while in the re-
mainin 11 (23%), the tumors were diagnosed as
enlarged lymph nodes and qualified for open bi-
opsy. After discovering tumors located at the bifur-
cation of the common carotid artery during the bi-
opsy, surgery was postponed and the patients were
transferred to the authors’ departments. The tu-
mors were labeled according to Shamblin’s classifi-
cation from 1971, based on the involvement of ca-
rotid vessels [1–9]. In the study group, 16 tumors
(33%) were Shamblin class I, 26 (53%) were class II
and seven (14%) were class III.

Results

All the patients were qualified for surgery. The
operations were performed under general anes-
thesia. After positioning the patient with the
head extended and rotated to the opposite side,
the incision was made along the anterior border
of the sternocleidomastoid muscle. Before tumor
removal, the carotid vessels and both vagal and
glossopharyngeal nerves were secured. Dissec-
tion started from the external carotid artery. Typ-
ically, the branches supplying the tumor were li-
gated in order to reduce intraoperative bleeding.
At the final stage, the internal carotid artery was
dissected. After total tumor excision, the length
of the internal carotid artery was assessed, because
it may have been displaced and elongated by tumor growth. In such cases, turning the head may cause the artery to fold and thus impair blood flow, increasing the risk of cerebral ischemia.

In the study group, 43 simple resections (88%) of the tumor were performed; however, 11 of those cases (22%) required vascular sutures in the area of common carotid artery bifurcation due to damage to the wall of the internal carotid artery. In 5 cases (10%), internal carotid artery repair was carried out along with tumor excision, due to folding of the vessel when the head was turned. Three cases (6%) required resection of the internal carotid artery because of its involvement; in 2 of these cases (4%), the vessel was replaced by a saphenous vein graft; and in 1 (2%), due to lack of an appropriate vein, the repair operation was performed by creating anastomosis between the external carotid artery and the distal portion of the internal carotid artery.

Out of 49 operations performed in 47 patients, 40 cases (82%) had an uncomplicated postoperative period. Three patients (6%) were reoperated due to symptoms of cerebral ischemia; in 2 of them, the symptoms resolved completely, while one died because of a massive stroke, probably provoked by chronic thrombus. Three patients (6%) developed paralysis of the hypoglossal nerve and 2 (4%) developed facial nerve paralysis. In 6 patients (12%), hematomas occurred in the postoperative wound, including 2 of the patients reoperated due to bleeding. In all the patients, the lymph nodes and internal organs were free from metastases. Histopathologic examinations confirmed that all the tumors were paragangliomas.

**Discussion**

Carotid paragangliomas are rare tumors that are mostly described in the literature as single case reports [17]. They are mainly unilateral. Fruhmann et al. reported 37 patients with unilateral and 10 with bilateral tumors, while Gad et al. studied 42 paraganglioma patients including only two bilateral cases [13, 18]. In the present study, 45 patients presented unilateral tumors, and two bilateral tumors. In the study by Gad et al., the average age of the patients was 45 years, which was similar to the average age in the current study [18]. According to Fruhmann et al., 20% of patients with paraganglioma carried an SDH gene mutation [13]. Genetic testing for SDHD, SDHB, SDHC and SDHAF, as well as VHL, RET and NF1, is recommended for paraganglioma patients under 40 years of age. SDH carriers require continued follow-up due to the higher risk of the development of multiple tumors [19, 20]. In paragangliomas, the risk of metastatic disease remains low [1]. Smith et al. estimate the risk of malignancy at less than 10% [18, 21].

Paragangliomas cause diagnostic and management difficulties. There is a lack of guidelines in the literature for the diagnosis and treatment of paraganglioma. Tumor diagnoses are based on imaging examinations such as Doppler duplex ultrasound, computed tomography angiography and magnetic resonance angiography [18]. Ultrasound examination is used for screening because it is non-invasive and widely available. Computed tomography and magnetic resonance help to evaluate the degree of the tumor. Angiography allows assessment of the vessels supplying the tumor and preoperative embolization [22–24].

Paragangliomas are challenging for surgeons due to their localization. Despite the lack of recommendations for treatment in the literature, radical resection is performed to prevent malignant transformation. Infiltration and damage to the arterial wall ranges from 20 to 25% [25, 26]. Luna-Ortiz et al. have modified Shamblin’s classification, labelling all class II tumors and those infiltrating vessels as Shamblin class III [27].

The clinical value of preoperative embolization remains controversial [28]. It can be considered in large tumors; however, it might increase the risk of transient ischemic attack and ischemic stroke. According to Qin et al. and Makeieff et al., embolization increases the possible complications during surgery [29, 30]. Netterville et al. state that the procedure can start the inflammatory process in the treated area and therefore increase the risk of damage to the carotid arteries during tumor excision [31]. Kakko et al. recommend embolization in tumors involving the carotid arteries and Shamblin class III lesions extending to the base of the skull [28]. In the present study group, embolization was not performed, and in the authors’ opinion, it does not improve the prognosis.

Radiotherapy can decrease the size of the tumor or stop its growth; therefore, it is recommended for patients with many diseases who are at risk during general anesthesia. In a study by Gilbo et al., out of 156 paraganglioma patients treated with radiotherapy, only 5 tumors showed a decrease in size, but a lack of tumor growth after 5 years was observed in 99% of the patients [7]. Surgical treatment is recommended for younger people because radiotherapy increases the risk of cancer development in the long term. Gilbo et al. also reported other radiotherapy complications, such as dry mouth, hearing loss and balance disorders [7].

Endarterectomy is the gold standard for paraganglioma. The incision is made parallel and anterior to the sternocleidomastoid. Carotid vessel...
reconstruction is considered optional [13]. Typical intraoperative complications include stroke and dysfunction or paralysis of cranial nerves IX–XII and VII [3, 6–20]. The complication rate is relatively high: Makeieff et al. reported 14%, and Gad et al. 17%. Fruhmann et al. reported cranial nerve paralysis in 20% of the patients, which was similar to the findings in the present study, in which this complication happened in 18% of the patients [13, 18, 30]. Standard paraganglioma operations can be performed with the use of water knife surgery. The stream of water allows for easier dissection of tissues, nerves and vessels, which is especially important in the area of the carotid artery bifurcation. The use of a water knife reduces intraoperative bleeding and the rate of vascular damage.

After surgery, paraganglioma patients require follow-up and regular imaging examinations. For patients with sporadic carotid body tumors, Fruhmann et al. recommend regular check-ups and ultrasound examinations of the neck, while for patients with genetic mutations, they recommend ultrasound examinations and resonance imaging angiography of the neck, head, chest, abdomen and pelvis [13]. In elderly patients in bad health, observation is the only possible approach [7].

The authors concluded that cooperation with an otolaryngologist and vascular surgeon during surgery is recommended due to frequent damage to carotid vessels by carotid paragangliomas. Detection of the tumor in an early stage improves surgical treatment outcomes and reduces the number of complications. Regular postoperative check-ups are necessary due to the possible occurrence of multiple tumors.

References

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