Preoperative Embolization of Carotid Chemodectoma: a Technical Challenge that Can Be Customized According to Angioarchitecture

Illustrative Cases

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SUMMARY – *Preoperative embolization of carotid paraganglioma is increasingly used to reduce the risk of surgical bleeding obtaining a more precise and extensive tumor resection. Currently the technique can be customized in consideration of the different tumor angioarchitecture, thanks to embolic materials with different vascular penetration: solid particles of polyvinyl-alcohol (PVA), histoacryl glue, and liquid polymer (Onyx®). Two cases of swelling dissection with volume progression over time came to our observation. Both patients (45 and 70-year-old women) were studied with neck ultrasound imaging and computed tomography (CT) and/or magnetic resonance (MR). In both cases the radiological investigations confirmed the clinical suspicion of carotid paraganglioma. Both patients were sent for angiography control and preoperative devascularization of the lesion. The treatment was performed under general anesthesia using, depending on the type of tumor vasculature, in case 1 solid particles of PVA and histoacryl glue, and in case 2 Onyx® (Covidien, Irvine). The patients successfully underwent excision of the lesion via cervicotomy within a week from the embolization procedure, without any complications. The histological findings confirmed the diagnosis of chemodectoma, and macrophage infiltrates were seen in the regions previously embolized. At one-year follow-up, there was no evidence of recurrent disease. The preoperative embolization of vascular lesions of the neck represents a safe technique that yields the best results when customized over the type of vascularization of the lesion, enabling the use of the most appropriate materials, depending on the case to be treated.*

Introduction

Preoperative embolization of vascular lesions of the head and the neck, such as paragangliomas, is routinely performed. A small paraganglioma does not usually require preoperative embolization because the risk may exceed the benefits, but angiography is mandatory in the diagnosis and treatment of large highly vascular paragangliomas¹. In respect of the anatomical and pathological characteristics of the

lesions and their angioarchitecture, the most appropriate approach can be identified, taking into account the different tools now available for preoperative devascularization^{2,3}.

Paraganglioma is usually a benign tumor derived from the highly vascularized diffuse neuroendocrine system, distributed from the base of the skull to the pelvis. Their extreme vascularity may be influenced by the presence of angiogenic growth factors-vascular endothelial growth factors and platelet-derived endothe-

Figure 1 Schematic image of surgical classification of chemodectoma based on the degree of involvement of the internal and external carotid arteries.

Figure 2 Case 1. A) The pre-treatment right common carotid artery anteroposterior angiographic view shows the intense blush at the carotid bifurcation corresponding to the glomus (arrows). B) Supraselective catheterization (arrows) of the principal arterial feeder to the tumor during the endovascular procedure. Note the tip of the microcatheter (small arrow). C) The postoperative right common carotid artery shows almost complete devascularization of the lesion at the final angiography control.

lial cell growth factor⁴. Embryological origin is from the neural crest (epithelioid cells), for this reason the lesions are associated with the parasympathetic nervous system⁵. Paraganglioma most commonly arises in the carotid body, jugular bulb, tympanic plexus on the promontory, and along the vagal nerve pathway or anywhere along the paraganglia pathway¹.

Tumors of the carotid body constitute less than 0.5% of all neoplasms, and the incidence of neck paragangliomas is around 2-8 cases/million/year. The mean age at diagnosis is 45 years; familiarity is present in 30-50% of the cases. In familial cases a larger plurilocation and early onset are often observed. The malignant potential ranges from two to 50% of cases⁶. Malignancy in paragangliomas is more common in sporadic non-familial patients than hereditary cases. Histologic examination of the tumor is not diagnostic of its malignant potential. The presence of tumor in lymph nodes or systemic metastases is the only acceptable criterion of malignancy⁴. A possible association with thyroid disease in familial cases has been also noted^{1,7}.

Chemoreceptor structures have a complex role in the homeostasis of arterial blood PaO₂ and pH control, while the carotid sinus also has baroreceptor function. Specimens are characterized by the presence of pathognomonic cells defined "zellballen" or "sub-tentacled"⁸: epithelioid cells with eosinophilic cytoplasm rich in secretory granules. Only 5% of the carotid paragangliomas are actively secreting⁹.

Histopathologically there are two typical patterns: type I, characterized by chief cells, granular cells with an organoid-nested pattern (zellballen), and type II, that has sustentacular cells. Both types I and II are rich in capillaries⁸.

Initially tumor expansion occurs within the carotid bifurcation and subsequently expands laterally involving the internal carotid and therefore also the external vessel. The tumor is well circumscribed by a richly vascularized fibrous capsule, then progresses involving the adventitia, media and intima (Shamblin classification)¹⁰ (Figure 1).

Most paragangliomas are asymptomatic lesions, with painless laterocervical swelling progression over time. In 25% of the cases, there is bruit at auscultation of the neck. Differential diagnosis includes: laterocervical lymph nodes, branchial cysts, parotid and salivary gland tumors, neurogenic tumors, carotid aneurysms, and neurofibromatosis. In order to

depict the secreting type, the biochemical assays include: normetanephrine, metanephrine and vanilmandelic acid. Diagnosis can also be achieved utilizing ECO bi-mode color Doppler, neck contrast-enhanced CT with CT angiography, angiography and contrast-enhanced neck MRI with typical "salt-and-pepper" images¹¹. If angiography is performed, it is important to selectively catheterize the ascending pharyngeal artery, that plays an important role in the anastomotic network between the external carotid artery, and the internal carotid and vertebral arteries¹².

Treatment includes surgery, without or with prior embolization, while the benefit of radiation therapy or radiosurgery is still largely debated^{13,14}. Radiation therapy is most considered in tumors with extensive intracranial or skull base involvement⁴.

Case Reports

Case 1

A 70-year-old woman with a history of slowly enlarging laterocervical mass located at the right carotid bulb with angiography appearance consistent with carotid glomus (Figure 2A). Due to the presence of a very long arterial feeder and a diffuse blush, superselective catheterization and subsequent arterial devascularization utilizing a mixture of PVA particles (80-150 micron) diluted in 50% contrast medium and saline were successfully performed (Figure 2B,C). At the end of the procedure, the main arterial feeder was obliterated utilizing histoacryl glue. A few days after embolization the patient underwent surgical resection of the tumor, and histology confirmed the diagnosis (Figure 3A,B).

Case 2

A 45-year-old woman with a left laterocervical pulsating mass and bruit at auscultation. The main arterial feeder was easily navigated with a microcatheter, and the highly vascularized mass was embolized utilizing liquid polymer Onyx[®], that was able to deeply penetrate the vascular nest of the tumor. The patient was operated on the day after the procedure, without any clinical or technical complications (Figure 4A-C). The histological appearance of the resected tumor with intravascular embolic agent it is shown in Figure 4D.

Figure 3 Histological features of paraganglioma (case 1) with the characteristic angioarchitecture. A) Nests of uniform neoplastic cells with vacuolated and eosinophilic cytoplasm embedded in fibrous septa with capillary vessels. B) Hematoxylin-eosin and immunostaining for synaptophysin. C) After embolization thrombosed vessels by unstructured embolic agent are recognizable, with a mild inflammatory reaction of the vessel walls.

Figure 4 Case 2. A) Laterolateral angiography of the left external carotid injection shows the chemodectoma, subsequently embolized utilizing liquid embolic agent (Onyx®). B) The cast of the polymeric glue is well recognizable in the non-subtracted lateral view (arrows) with extensive devascularization at the final angiography control (in C). D) Light microscopic view of the excised tumor demonstrating paraganglioma including ectatic embolized vessels with thickened wall infiltrated by macrophages and inflammatory cells, and granular and amorphous foreign material in the lumen.

Discussion and Conclusion

At present, in case of vascularized tumors, the materials for embolization include polyvinyl-alcohol particles (PVA), liquid polymer Onyx® and histoacryl glue¹⁵.

PVA particles present variable vessel penetration, depending on the size of the particles, and are generally indicated in case of distal microcatheterization, such as in our “case 1”. Devascularization generally progresses during the following days, so that surgery should be per-

formed a few days after the embolization procedure, in order to permit progression of the mass thrombosis avoiding recanalization or neovascularization of the embolized mass over time³.

Onyx® is characterized by high vessel penetration and, due to the almost immediate polymerization, surgery can be done right away (case 2)^{2,3,16}.

In our cases the embolization was performed under general anesthesia and systemic anticoagulation in order to achieve the best result reducing undesired thromboembolic events. In fact, the most dreaded complications include vasa nervorum embolization with subsequent nerve palsy, and leakage of embolic material into normal vessels, due to reflux over the feeder, or to opening of vessel anastomosis, with subsequent ischemia or stroke^{3,4}. A thorough knowledge of the regional vascular anatomy is essential to reduce the risks related to this procedure as far as possible¹². Postembolization paragangliomas often manifest a reduction in tumor size as much as 25% as a result of diminished tumoral blood flow⁴.

Histoacryl glue vascular penetration is less

predictable than PVA and Onyx. This is why in case 1 after devascularization of the tumor mass with PVA, glue was utilized just at the end of the procedure only to plug the main arterial feeder to the tumor.

In our cases both devascularization procedures were uneventful. At operation, tumor excision was reasonably easy, without any significant bleeding. Tumor removal was manageable without any technical disadvantage due to the presence of the embolic agent, unlike complaints by some surgeons operating on tumors preoperatively embolized utilizing N-butyl cyanoacrylate glue (histoacryl®), mostly due to its hardness.

In conclusion, the preoperative embolization of vascular lesions of the neck, such as chemodectoma, is a safe technique that can be extremely supportive to the surgical approach, particularly when a targeted strategy is pursued. It should be performed by experienced hands and to obtain the best results embolization has to be customized according to the angioarchitecture of the lesion, using the most appropriate materials depending on the case to be treated.

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