Learning objectives

- Briefly review the epidemiology, pathogenesis and clinical features of paragangliomas.

- Identify the distinctive imaging features of paragangliomas on CT and MR that allow radiologists to suggest the correct diagnosis.

- Present some common manifestations of head and neck paragangliomas, illustrating some of them with images collected over a 4-year period (from June 2010 to June 2014) in our institution.
Background

Paragangliomas are tumors arising from a specialized tissue called paraganglia, a chain of extraadrenal neuroendocrine cells of neuroectodermal origin (arising from the neural crest) that is spread throughout the body, habitually near nerves and vascular structures. These lesions are composed of islets of cells separated by abundant vascular channels and a fibrous matrix.

They are frequently called glomus tumors, because of the extensive arborization of nerves and blood vessels within these lesions.

These are uncommon tumors, accounting for approximately 0.03% of all neoplasms and 0.6% of all neoplasms of the head and neck.

Two thirds of cases of paragangliomas are diagnosed between the ages of 40 and 60.

Paragangliomas frequently present as solitary masses, but they can also be multicentric. When multicentric, they may occur synchronously or metachronously.

Although most frequently sporadic, about 7-9% are related to familial occurrence, particularly lesions from the carotid body. Familial paragangliomas tend to occur in younger patients, and mode of transmission is autosomal dominant with incomplete penetrance.

Uncommonly, they may be hormonally active and secrete catecholamines, being called functioning paragangliomas.

Paragangliomas usually have a benign behavior, however, cases of malignancy with extension to regional lymph nodes or distant metastasis (lungs, skull, lymph nodes, heart, liver, pancreas, pleura, dura mater and skin) have been described. The only definitive criteria for malignancy is the presence of metastatic disease. When there is capsular or vascular invasion or necrosis, one must always suspect a malignant behavior. Mortality rates in these cases are significant, estimated at 9-15%, according to tumor location.

Local recurrence and local invasion rates are high, reaching 40%-50% in glomus jugulare tumors, being lower in vagal paragangliomas and carotid body tumors.

Knowing the distribution of the paraganglionic system helps to understand the most frequent locations where paragangliomas arise. Within the head and neck, these locations include the carotid body, the jugular foramen, the middle ear and along the path of the vagus nerve. Much less common locations include the sella turcica, the pineal gland, the cavernous sinus, the orbit, the thyroid gland, the nasopharynx and larynx, the soft palate or the mandible.
**Paragangliomas of the carotid body** usually arise at the common carotid artery bifurcation or, less frequently, along the path of either the external carotid artery or the internal carotid artery. These well-defined, lobulated solid masses have a fibrous pseudocapsule and are usually homogeneous, although foci of necrosis, sclerosis and cystic change have been described.

These lesions have a slow rate of growth, but as they grow, they may extend cranially to the skull base and intracranial compartment or caudally to the lower cranial nerves and pharynx.

**Glomus jugulare** tumors arise within the jugular foramen, originating either from the jugular bulb, Jacobson nerve (a small tympanic branch of the glossopharyngeal nerve on the cochlear promontory) or Arnold nerve (the auricular branch of the vagus nerve). They do not primarily involve the middle ear. They usually spread throughout the paths of least resistance - vascular structures, mastoid air cells, eustachian tube and neural foramina.

**Glomus tympanicum** arise from tissue remnants found along the Jacobson or Arnold nerve. They represent the second most common neoplasm of the temporal bone (the most common being acoustic schwannoma), and may be confined to the middle ear or extend to the mastoid air cells posteriorly.

**Glomus jugulotympanicum** describes a paraganglioma envolving both the jugular foramen and the middle ear. It represents a jugular foramen mass that extends superolaterally into the floor of the middle ear cavity.

**Vagus nerve paragangliomas** are the rarest of major head and neck paragangliomas, and may arise anywhere along the course of the nerve, but more commonly originate from glomus tissue remnants in the inferior (nodose) ganglion or the superior (jugular) ganglion. In these two locations, they have different characteristics. Paragangliomas arising from the inferior ganglion are spindle shapped, displace the carotid vessels anteromedially and the pharynx wall medially, and may compress the internal jugular vein. Paragangliomas arising from the superior ganglion are "dumbbell shaped" and may extend intracranially, to the posterior fossa, or inferiorly to the infratemporal area. As they grow, involvement of middle ear structures is also possible.

Clinical features depend on tumor location.

Carotid body paragangliomas appear as a slowly growing, movable, pulsatile lateral neck mass, near the angle of the mandible. Patient may be asymptomatic or complain about tinnitus, vertigo, hoarseness, stridor, tongue paresis or dysphagia.
Vagal paragangliomas also appear as slow growing, painless masses in the lateral neck, most frequently behind the angle of the mandible, a less common location being the oral cavity. Patient complaints are related to vagal nerve deficits, and include Horner syndrome (owing to infiltration of the cervical sympathetic chain), hoarseness or vocal cord paralysis. Symptoms related to involvement of the hypoglossal, accessory or glossopharyngeal nerves may occur late in the course of the disease.

Glomus jugulare causes pulsatile tinnitus and presence of a retrotympanic vascular mass.

Glomus tympanicum typically causes pulsatile tinnitus, vertigo and conduction hear loss.
Findings and procedure details

Paragangliomas have distinct characteristic findings on imaging studies, allowing exclusion of other differential diagnosis. And to a certain extent, computed tomography (CT) and Magnetic Resonance (MR) are complementary techniques. Choice of performing CT or MR first and also of performing a second imaging study will depend on the radiologist preference and the availability of these techniques in different institutions.

Both CT and MR accurately demonstrate the highly vascular nature of these soft-tissue masses, which avidly enhance after intravenous contrast administration.

MR depicts paragangliomas smaller than 5mm, while CT hardly demonstrates lesions smaller than 8mm. MR allows better definition of tumor location and extent, as well as more accurate characterization of these masses than CT. Involvement of the internal carotid artery and internal jugular vein is also more evident on MR.

However, CT is much better than MR in demonstrating the relation between tumor and structures of the middle ear (such as the ossicles and semicircular canals) and in characterizing changes in bone structures of the skull base and middle ear.

Computed tomography

On CT, paragangliomas usually appear as well-circumscribed hypervascular soft-tissue masses, showing avid and homogeneous enhancement following intravenous contrast administration.

Specific features exist according to different tumor locations.

Carotid body paragangliomas normally splay the common carotid bifurcation, as mentioned above.

Rarely, larger lesions may exhibit heterogeneous enhancement due to the presence of focal thrombi or hemorrhage. In about 8% of cases, cranial extension into the suprahypoid neck may be seen. As tumor enlarges, it may encase but does not narrow the caliber of the external and internal carotid arteries.

Vagal paraganglioma displaces the internal (and sometimes also the external) carotid artery anteromedially and the internal jugular vein posteriolaterally. Cranial extension into
the suprathyoid neck is more frequent than with carotid body tumors (in two-thirds of vagal paragangliomas).

**Glomus jugulare** (Fig 1-8) characteristically cause expansion and erosion of the jugular foramen, that becomes enlarged and with irregular margins. This bone erosion pattern with permeative-destructive changes, is called moth-eaten. As tumor grows, it may spread to the surrounding bony labyrinth, often resulting in osteonecrosis. It may also cause dehiscence of the inferior wall of the tympanic cavity and invasion of the mesotympanum, leading to ossicular chain destruction. Tumor may also spread cranially and infiltrate the internal jugular vein and and infratemporal fossa. Lateral spreading leads to destruction of the facial nerve canal and subsequent nerve infiltration. Intracranial posterior spread is also possible, and tumor may reach this compartment directly through the petrous bone, through the acoustic meatus directly into the cerebellopontine angle or via the infralabyrinthine-inframeatal path into the cerebellomedullary angle.

**Glomus tympanicum** (Fig 9-14) appears as a round mass with flat base on the cochlear promontory, projecting into the mesotympanum, and confined to the tympanic cavity. Large lesions may encase the ossicular chain, but ossicular destruction is rare. Extension into the mastoid air cells or into the eustachian canal and nasopharynx is possible but highly infrequent.

**Glomus jugulotympanicum** (Fig 15-19) appears a mass in the jugular foramen spreading into the middle ear, causing permeative-destructive changes along the superolateral margin of the jugular foramen.

**Magnetic Resonance**

Paragangliomas typically display low signal intensity on T1-weighted (T1-W) sequences and high signal intensity on T2-weighted (T2-W) sequences.

In larger tumors (>2cm), multiple punctate and serpiginous areas of signal void may be seen on T2-W sequences, representing high-velocity flow in tumor vessels. This is the so called "salt-and-pepper" appearance, "salt" (hyperintense foci) representing slow flow or subacute hemorrhage and "pepper" representing multiple areas of flow voids.

However, this feature is not patognomonic of paragangliomas, since other hypervascular lesions (metastatic hypernephroma, metastatic thyroid carcinoma) may also display it.

Homogeneous and intense enhancement after intravenous contrast administration completes MR features of paragangliomas.
If necessary, MR venography can be performed in order to distinguish glomus jugulare from vascular anomalies such as simple asymmetric enlargement of the jugular foramen, high-riding or dehiscent jugular bulb and jugular vein thrombosis.
Fig. 1: Gloms jugulare: Patient with sudden deafness on the right side. Axial CT with bone window setting - marked asymmetry between the jugular bulb and superior cervical segment of the internal jugular vein, which are larger on the right side, on account of a soft tissue lesion occupying this area. It causes slight erosion of the jugular spine and posterior wall of the vertical segment of the internal carotid artery. There are no other erosive changes of the skull base. There is no tympanic component.

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Fig. 2: Gloms jugulare: Patient with sudden deafness on the right side- Axial CT with bone window setting - marked asymmetry between the jugular bulb and superior cervical segment of the internal jugular vein, which are larger on the right side, on account of a soft tissue lesion occupying this area. It causes slight erosion of the jugular spine and posterior wall of the vertical segment of the internal carotid artery. There are no other erosive changes of the skull base. There is no tympanic component.

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Fig. 3: Glomus jugulare: Patient with sudden deafness on the right side- Axial CT with bone window setting - marked asymmetry between the jugular bulb and superior cervical segment of the internal jugular vein, which are larger on the right side, on account of a soft tissue lesion occupying this area. It causes slight erosion of the jugular spine and posterior wall of the vertical segment of the internal carotid artery. There are no other erosive changes of the skull base. There is no tympanic component.

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Fig. 4: Right glomus jugulare with extension to the cerebellopontine angle: MR sagittal T1-W - Expansive lesion centered on the right jugular bulb, extending inferiorly to the level of C2-C3 and superiorly to the posterior fossa (intracranial component), where it has a cisternal component that contacts the right cerebellar hemisphere and middle cerebellar peduncle. This lesions avidly enhances after intravenous contrast administration, exhibiting areas of flow voids inside. There is no tympanic component and there is no extension to the right sigmoid or lateral sinus.

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Fig. 5: Right glomus jugulare with extension to the cerebellopontine angle: MR axial FLAIR T2-W - Expansive lesion centered on the right jugular bulb, extending inferiorly to the level of C2-C3 and superiorly to the posterior fossa (intracranial component), where it has a cisternal component that contacts the right cerebellar hemisphere and middle cerebellar peduncle. This lesion avidly enhances after intravenous contrast administration, exhibiting areas of flow voids inside. There is no tympanic component and there is no extension to the right sigmoid or lateral sinus.

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Fig. 6: Right glomus jugulare with extension to the cerebellopontine angle: MR coronal T2-W Fat-Sat - Expansive lesion centered on the right jugular bulb, extending inferiorly to the level of C2-C3 and superiorly to the posterior fossa (intracranial component), where it has a cisternal component that contacts the right cerebellar hemisphere and middle cerebellar peduncle. This lesion avidly enhances after intravenous contrast administration, exhibiting areas of flow voids inside. There is no tympanic component and there is no extension to the right sigmoid or lateral sinus.

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Fig. 7: Right glomus jugulare with extension to the cerebellopontine angle: MR axial 3D FIESTA - Expansive lesion centered on the right jugular bulb, extending inferiorly to the level of C2-C3 and superiorly to the posterior fossa (intracranial component), where it has a cisternal componente that contacts the right cerebellar hemisphere and middle cerebellar peduncle. This lesions avidly enhances after intravenous contrast administration, exhibiting areas of flow voids inside. There is no tympanic component and there is no extension to the right sigmoid or lateral sinus.

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Fig. 8: Right glomus jugulare with extension to the cerebellopontine angle: MR sagital FSPGR 3D Fat Sat (intravenous contrast administration) - Expansive lesion centered on the right jugular bulb, extending inferiorly to the level of C2-C3 and superiorly to the posterior fossa (intracranial component), where it has a cisternal componente that contacts the right cerebellar hemisphere and middle cerebellar peduncle. This lesions avidly enhances after intravenous contrast administration, exhibiting areas of flow voids inside. There is no tympanic component and there is no extension to the right sigmoid or lateral sinus.

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Fig. 9: Tympanic paraganglioma - Axial CT with bone window setting: Soft-tissue mass with well-defined margins in the left ear, adherent to the promontory. The lesion reaches the malleus and also reaches the level of the round window, without occlusion. The ossicular chain, the petrous pyramid and the mastoid are intact. Focally contacts the wall of the carotid canal, where a small fissure is seen (red arrow). Passage of a small arterial branch through this fissure cannot be excluded.

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Fig. 10: Tympanic paraganglioma - Axial CT with bone reconstruction: Soft-tissue mass with well-defined margins in the left ear, adherent to the promontory. The lesion reaches the malleus and also reaches the level of the round window, without occlusion. The ossicular chain, the petrous pyramid and the mastoid are intact. Focally contacts the wall of the carotid canal, where a small fissure is seen. Passage of a small arterial branch through this fissure cannot be excluded.

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Fig. 11: Tympanic paraganglioma - Coronal CT with bone reconstructions: Soft-tissue mass with well-defined margins in the left ear, adherent to the promontory. The lesion reaches the malleus and also reaches the level of the round window, without occlusion. The ossicular chain, the petrous pyramid and the mastoid are intact. Focally contacts the wall of the carotid canal, where a small fissure is seen. Passage of a small arterial branch through this fissure cannot be excluded.

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**Fig. 12:** Tympanic paraganglioma recurrence - Patient with previous tympanic paraganglioma two years before, surgically removed. Follow-up; Axial CT with bone window setting: Small and well-defined lesion in the anterior hypotympanic area, adjacent to the carotid wall and the cochlear promontory and in contact with the tympanic membrane. No tympanic, mastoid or internal ear pathologic features were found. Post-surgical anatomopathological examination confirmed paraganglioma (recurrence).

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Fig. 13: Tympanic paraganglioma recurrence - Patient with previous tympanic paraganglioma two years before, surgically removed. Follow-up; Axial CT with bone reconstruction: Small and well-defined lesion in the anterior hypotympanic area, adjacent to the carotid wall and the cochlear promontory and in contact with the tympanic membrane. No tympanic, mastoid or internal ear pathologic features were found. Post-surgical anatomopathological examination confirmed paraganglioma (recurrence).

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**Fig. 14:** Tympanic paraganglioma recurrence - Patient with previous tympanic paraganglioma two years before, surgically removed. Follow-up; Coronal CT with bone reconstruction: Small and well-defined lesion in the anterior hypotympanic area, adjacent to the carotid wall and the cochlear promontory and in contact with the tympanic membrane. No tympanic, mastoid or internal ear pathologic features were found. Post-surgical anatomopathological examination confirmed paraganglioma (recurrence).

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**Fig. 15:** Jugulotympanic glomus: MR axial T1-W - Expansive soft tissue mass of the skull base, centered on the right foramen lacerum, involving the tympanic cavity at the level of the hypotympanum and extending to the posterior fossa, partly occupying the lateral segment of the right bulbar and pontocerebellar cisterns. There is circumferential involvement of the vertical segment of the intrapetrous internal carotid artery, without narrowing its caliber. The lesion extends to the right sigmoid sinus and internal jugular vein, filling its lumen. It also contacts the anterior cerebellar hemisphere. There is no mass effect on the cerebral trunk.

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**Fig. 16:** Jugulotympanic glomus: MR axial T2-W - Expansive soft tissue mass of the skull base, centered on the right foramen lacerum, involving the tympanic cavity at the level of the hypotympanum and extending to the posterior fossa, partly occupying the lateral segment of the right bulbar and pontocerebellar cisterns. There is circumferential involvement of the vertical segment of the intrapetrous internal carotid artery, without narrowing its caliber. The lesion extends to the right sigmoid sinus and internal jugular vein, filling its lumen. It also contacts the anterior cerebellar hemisphere. There is no mass effect on the cerebral trunk.

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Fig. 17: Jugulotympanic glomus: MR coronal T2-W - Expansive soft tissue mass of the skull base, centered on the right foramen lacerum, involving the tympanic cavity at the level of the hypotympanum and extending to the posterior fossa, partly occupying the lateral segment of the right bulbar and pontocerebellar cisterns. There is circumferential involvement of the vertical segment of the intrapetrous internal carotid artery, without narrowing its caliber. The lesion extends to the right sigmoid sinus and internal jugular vein, filling its lumen. It also contacts the anterior cerebellar hemisphere. There is no mass effect on the cerebral trunk.

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Fig. 18: Jugulotympanic glomus: MR axial T1-W Fat Sat + Gadolinium - Expansive soft tissue mass of the skull base, centered on the right foramen lacerum, involving the tympanic cavity at the level of the hypotympanum and extending to the posterior fossa, partly occupying the lateral segment of the right bulbar and pontocerebellar cisterns. There is circumferential involvement of the vertical segment of the intrapetrous internal carotid artery, without narrowing its caliber. The lesion extends to the right sigmoid sinus and internal jugular vein, filling its lumen. It also contacts the anterior cerebellar hemisphere. There is no mass effect on the cerebral trunk. There is intense enhancement after intravenous contrast administration.

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Fig. 19: Jugulotympanic glomus: MR coronal T1-W Fat Sat + Gadolinium - Expansive soft tissue mass of the skull base, centered on the right foramen lacerum, involving the tympanic cavity at the level of the hypotympanum and extending to the posterior fossa, partly occupying the lateral segment of the right bulbar and pontocerebellar cisterns. There is circumferential involvement of the vertical segment of the intrapetrous internal carotid artery, without narrowing its caliber. The lesion extends to the right sigmoid sinus and internal jugular vein, filling its lumen. It also contacts the anterior cerebellar hemisphere. There is no mass effect on the cerebral trunk. There is intense enhancement after intravenous contrast administration.

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Conclusion

- Paragangliomas, also called glomus tumors, are slow-growing, highly vascularized uncommon lesions of the head and neck region.

- Most usual locations include the carotid body and common carotid artery bifurcation, the jugular foramen and the middle ear.

- Although most frequently benign, infrequent cases of malignant behavior with presence of metastatic disease have been described.

- To a certain extent, CT and MR are complementary techniques, both accurately demonstrating the hypervascular nature of these soft-tissue masses. Each has its advantages and disadvantages, MR being superior in demonstrating small (<5mm) lesions and in obtaining more precise information about tumor location, extent and characteristics, and CT being superior in the evaluation of associated bone changes.

- Familiarization with the distribution of the paraganglionic system and the imaging features of paragangliomas on CT and MR helps radiologists suggest an accurate diagnosis.
References

