Learning objectives

1) To describe 13 classic signs in neuroradiology.

2) To provide illustrations of these signs.

3) To discuss the pertinent features related to each sign with emphasis on the cause of the appearance of these signs, and the differential diagnoses to be considered.

Background

• The language of radiology is rich with descriptions of imaging findings, often metaphorical, which have found common usage in the day-to-day practice of radiology.
• Classic signs in radiology, when invoked, immediately bring an image to mind and add confidence to the diagnosis of certain conditions.
• This presentation reviews 13 classic signs in neuroradiology. The authors discuss the most important features related to each sign and provide illustrations of these signs using different imaging modalities, schematic drawings and/or pictures. They also address the differential diagnoses.

Imaging findings OR Procedure details

1- ICE-CREAM CONE SIGN

The ice-cream cone sign represents the normal appearance of the malleus and incus on an axial high-resolution CT scan image of the temporal bone (figure 1). The ball (scoop) of the ice cream is formed by the head of malleus and the cone is formed by the body of the incus (1).

2- LEMON SIGN

The lemon sign refers to the shape of the fetal skull at ultrasonography (US) obtained at the biparietal diameter level, when the frontal bones lose their normal convex contour and appear flattened or inwardly scalloped (figure 2). This gives the skull a shape similar to
that of a lemon. It can be falsely produced by angling the probe downward and anteriorly to include the orbit (1,2).

This sign is very useful in the detection of spina bifida before 24 weeks of gestation in high-risk patients. It may disappear as gestational age advances and hence it is less reliable after 24 weeks. A study found that in fetuses with spina bifida examined before 24 weeks of gestation, this sign had a high sensitivity (93%), a high specificity (99%), and a positive predictive value of 81%. The sign is not specific for spina bifida and has been seen in a variety of conditions (2).

**Differential diagnosis:** encephalocele, Dandy-Walker malformation with encephaloceles, thanatophoric dysplasia, cystic hygroma, diaphragmatic hernia, agenesis of the corpus callosum, fetal hydronephrosis, and umbilical vein varix and two-vessel cord (2).

3- **HARLEQUIN APPEARANCE**

**Harlequin appearance** of the orbit represents the elevation of the superolateral angle of the orbit along with a flat frontal bone on a plain radiograph (figure 3). The orbit is shallow, the lesser wing is elevated and the greater wing is expanded; on posteroanterior skull radiographs this distortion causes the superior border of the greater wing of the sphenoid to appear as a heavy dense ridge as it passes upward and outward (1).

It is seen in coronal craniosynostosis, where the anteroposterior growth of the skull is limited. There is also relative increase in the transverse diameter of the skull, which is called brachycephaly. The sign can be unilateral or bilateral (1).

4- **BARE ORBIT SIGN**

The **bare orbit sign** refers to the appearance of the orbit on a frontal radiograph of the skull and is so called because of the absence of the innominate line, which is the projection of the greater wing of the sphenoid bone (figure 4). In addition to the absence of the innominate line, there is egg-shaped enlargement of the anterior orbital rim, a bony defect in the posterior orbit, and anteroposterior enlargement of the middle cranial fossa.

This sign is seen in sphenoid wing dysplasia in neurofibromatosis type 1 (NF1). Sphenoid wing dysplasia is found in 5-10% of cases of NF1 and is used as one of the National Institute of Health (NIH) diagnostic criteria for NF1 (1,3).
The exact mechanism for the sphenoid bone changes seen associated with neurofibromatosis is uncertain. Abnormal skull development, altered transmission of CSF pulsations and interaction between plexiform neurofibroma and sphenoid bone are postulated as possible mechanisms (3,4).

5- HYPERDENSE MCA SIGN

This sign refers to the hyperdense middle cerebral artery (MCA) seen on nonenhanced CT scan images in acute stroke (figure 5). The hyperdense MCA sign, a marker of thrombus in the MCA, has been recognized as a harbinger of a subsequent large cerebral infarction by CT.

Hyperdensity of the MCA is a result of acute clot formation within the artery. The sign is said to be seen usually within approximately 90 min of the event. It has a high specificity of almost 100% but a very low sensitivity of 30% in the diagnosis of acute stroke. It is suggestive of occlusion of the MCA but does not necessarily represent infarction of the brain parenchyma (1,5).

6- EMPTY DELTA SIGN

The empty delta, empty triangle, or negative delta sign on contrast-enhanced CT scans of the brain consists of a V-shaped or triangular pattern of enhancement surrounding a central, relatively hypodense area. The sign is created by a nonenhancing thrombus in the dural sinus surrounded by triangular enhancing dura as seen on cross-section (figure 6) and suggests dural sinovenous thrombosis. The empty delta sign is the best and most frequently seen CT sign of sagittal sinus thrombosis, present in approximately 35% of published cases (1,6,7). The use of multislice contrast-enhanced CT scan, with reconstructions into thinner slices in different planes, markedly improves the yield.

The sign may not be seen in the early stage (less than 5 days) of thrombosis, as the fresh clot is hyperdense, or in the late stage (after more than 2 months), as numerous channels of recanalization develop in the thrombus after 2 months.

As yet, no universally accepted pathophysiologic explanation for the appearance of this sign exists. However, numerous hypotheses include (a) recanalization of the thrombus...
within the sinus, (b) organization of the clot, (c) blood-brain barrier breakdown, and (d) dilatation of collateral peridural and dural venous channels (6,7).

**Differential diagnosis:**

'**pseudodelta' sign**' on unenhanced CT scan (hyperdense subarachnoid hemorrhage, subdural empyema, hematoma surrounding the sinus), high tentorial insertion in children (1,7).

7- **MOYA MOYA APPEARANCE**

**Moya moya** ("puff of smoke") is a term introduced by Japanese investigators in 1969 to describe a telangiectatic cerebrovascular pattern in a series of Japanese children with hemiplegia. **Moya moya appearance** represents the angiographic appearance of basal telangiectasias, which consist of dilated collateral branches of the lenticulostriate and thalamostriate arteries (figure 7). It is usually seen in the anterior circulation in association with internal carotid artery stenosis.

When the **moya moya appearance** is seen along with idiopathic occlusion of the internal carotid arteries it is called moya moya disease; when the occlusion is secondary to some other disease it is called **moya moya syndrome**. Causes of **moya moya syndrome** include NF1, sickle cell disease, bacterial meningitis, polyarteritis nodosa, radiation therapy, tuberculosis, and atherosclerosis. Children with moya moya usually have ischemia or infarction, while adults with moya moya usually have hemorrhage (8).

8- **MEDUSA HEAD SIGN**

**"Medusa head" sign** is considered as a typical CT, MR, and angiographic appearance of venous malformations. It is seen in a developmental venous anomaly (DVA), where multiple tributaries arranged in a radial fashion drain into a larger vein (figure 8) and this appearance resembles Medusa's (Greek) head (caput, Latin) after her unfortunate transformation (1,9).

This sign is best seen on gadolinium-enhanced T1 weighted images (T1WI). DVAs are usually located in the juxtacortical and periventricular regions and are commonly seen in the frontal and parietal lobes and in the brachium pontis. In most cases they are asymptomatic or present unspecific clinical symptoms (headache, seizures, focal signs). The frequency of hemorrhage is evaluated at around 0% to 15-30% (1).
Mythology: Medusa, a beautiful woman, is bedded with Poseidon, the god of the sea, in one of Athena's temples. Poseidon desecrated Athena's temple by lying in it with Medusa, to spite his fellow deity with whom he maintained a long rivalry. Medusa, on the other hand, was a mere mortal and left vulnerable to Athena's rage. The angered goddess promptly turned Medusa's golden wavy hair into living snakes (9).

9- DURAL TAIL SIGN

This sign represents thickening and enhancement of the dura mater in continuity with a mass, which on MR images, gives the appearance of a tail arising from the mass (figure 9). The dural tail is thought to represent reactive change; however, it may also be due to tumor invasion. Three criteria need to be met for a 'positive' dural tail sign: the tail should be seen on two successive images through the tumor, it should taper away from the tumor, and it must enhance more than the tumor.

This sign has been traditionally considered as highly specific for meningioma. However, it is seen only in 60% of meningiomas.

Differential diagnosis: chloromas, primary CNS lymphomas, sarcoidosis, schwannomas, metastases, and syphilitic gummata (1,10,11)

10- SALT AND PEPPER SIGN

This sign is seen on MRI images in paragangliomas such as glomus tumors (figure 10). The sign is indicative of the hypervascularity of the mass. The 'pepper' represents multiple areas of signal void of vessels and the 'salt' represents the hyperintense foci due to slow-flow vessels or hemorrhages in these hypervascular tumors. The sign is seen in tumors that are more than 1 cm in diameter and is not specific for paragangliomas.

Paragangliomas can be multiple and bilateral, especially in familial cases, and hence evaluation of the entire neck and of both sides is needed. Four common locations of paragangliomas in the head and neck are the carotid body, the jugular foramen, along the path of the vagus nerve, and the middle ear. (1,12).

Differential diagnosis:

metastatic hypernephroma and metastatic thyroid carcinoma (hipervascular lesions).
11- OPTIC NERVE TRAM-TRACK SIGN

A tram-track sign is composed of two enhancing areas of tumor separated from each other by the negative defect of the optic nerve. It is seen on contrast-enhanced CT scan and MRI images (figure 11), in optic nerve sheath meningioma. The sign helps distinguish between optic nerve sheath meningioma and optic glioma. Optic glioma arises from glial cells within the optic nerve and there is no clear separation between the nerve and the tumor; hence the tram-track sign is not seen in optic gliomas.

Optic nerve meningioma is usually seen in women in the third to fifth decades of life and in children with neurofibromatosis type 2, where it may be bilateral. The tram-track sign is not specific for meningiomas (1,13).

Differential diagnosis: orbital pseudotumor, perioptic neuritis, sarcoidosis, leukemia, lymphomas, metastases, perioptic hemorrhages, and Erdheim-Chester disease (1,13).

12- EYE-OF-THE-TIGER SIGN

This sign represents marked low signal intensity of the globus pallidi on T2W MRI images. This low signal surrounds a central, small hyperintense area, producing the eye-of-the-tiger appearance (figure 12). The eye-of-the-tiger sign is most commonly referenced in association with Hallervorden-Spatz syndrome (HS) which is now called neurodegeneration with brain iron accumulation (NBIA) or pantothenate kinase II (PANC2)-associated neurodegeneration.

The marked low signal intensity of the globus pallidi is a result of excessive iron accumulation and the central high signal is attributed to gliosis, increased water content, and neuronal loss with disintegration, vacuolization, and cavitation of the neuropil (1,14).

Differential diagnosis:
cortical-basal ganglionic degeneration, early-onset levodopa-responsive parkinsonism, and Steele-Richardson-Olszewski syndrome (progressive supranuclear palsy) (14).

13- STRIPE SIGN/ TIGROID PATTERN
The **stripe sign** is seen as linear hypointensities radiating from the ventricular margins within hyperintense periventricular white matter and the centrum semiovale on T2W MRI images (figure 13). The sign represents a specific pattern of demyelination, with sparing of perivascular white matter. The spared perivascular white matter is seen as dark spots or dark linear areas against a background of bright affected white matter, giving the appearance of the skin of a leopard.

It is seen in metachromatic leukodystrophy (MLD) which is an autosomal recessive disorder with deficiency of the lysosomal enzyme arylsulfatase, leading to accumulation of sulfatides in the brain, peripheral nerves, kidneys, liver, and gall bladder. Clinically, children present with peripheral neuropathy and changes in intellect, speech, and coordination. The disease is progressive, with gait abnormality, quadriplegia, decerebration, and death by the age of 6 months to 4 years.

MRI shows symmetric increased signal in the periventricular white matter, with initial sparing of the subcortical U fibers. No enhancement is seen in the brain tissue unlike in adrenoleukodystrophy. However, cranial nerve enhancement has been reported recently in MLD (1,15).

**Images for this section:**
Fig. 1: FIGURE 1- ICE CREAM CONE SIGN. Axial temporal bone CT. Picture and schematic drawing.

Fig. 2: FIGURE 2- Axial sonogram of a fetal head demonstrating the lemon sign. Schematic drawing and picture.
**Fig. 3:** FIGURE 3- Skull AP radiograph shows HARLEQUIN APPEARANCE. Schematic drawing and picture of a mask.
Fig. 4: FIGURE 4- Frontal radiograph of the skull. Absence of the innominate line (arrow). BARE ORBIT SIGN. Schematic drawing.
Fig. 5: FIGURE 5- Axial nonenhanced head CT scan shows hyperdense middle cerebral artery (MCA). Schematic drawing.
Fig. 6: FIGURE 6- EMPTY DELTA SIGN. Note empty triangle on contrast-enhanced CT of the brain (thrombus in the dural sinus). Schematic drawing.
**Fig. 7:** FIGURE 7- Moyamoya angiographic pattern. Schematic drawing and picture.

**Fig. 8:** FIGURE 8- MEDUSA HEAD SIGN. MR shows venous malformation. Multiple tributaries arranged in a radial fashion drain into a larger vein (arrows).
Fig. 9: FIGURE 9- DURAL TAIL. Coronal T1-WI MR shows enhancement of the dura mater in continuity with a mass. Meningioma (arrows).
Fig. 10: FIGURE 10- SALT AND PEPPER SIGN. Axial MRI demonstrates the salt and pepper appearance due to the hypervascularity of this right mass (paraganglioma).
Fig. 11: FIGURE 11- OPTIC NERVE TRAM-TRACK SIGN. Contrast-enhanced CT scan and MRI images demonstrate tram-track sign (two enhancing areas of tumor separated from each other by the negative defect of the optic nerve)in two different cases of optic nerve sheath meningioma.

Fig. 12: FIGURE 12- EYE-OF-THE-TIGER SIGN. Axial T2-WI MR shows low signal surrounding a central, small hyperintense area, producing the eye-of-the-tiger appearance in the globus pallidus bilaterally (arrows). Hallervorden-Spatz disease.
Fig. 13: FIGURE 13- STRIPE SIGN/TIGROID PATTERN. Linear hypointensities radiating from the ventricular margins within hyperintense periventricular white matter and the centrum semiovale on T2W MRI axial image. Schematic drawings and pictures.
Conclusion

Familiarity with these signs helps in arriving at a diagnosis in day-to-day practice. Newer imaging modalities may render some signs obsolete, but they do not change the basic pathophysiology on which the signs are based.

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Fig. 1: RECIFE - PERNAMBUCO - BRAZIL *AUTHORS
References