PUPIL AND ACCOMODATION ABNORMALITIES
Sympathetic pathway of pupillary innervation

1. hypothalamus
2. T1
3. superior cervical ganglion
4. carotid artery
5. cavernous sinus to nasociliary nerve and ophthalmic artery
6. dilator pupillae lacrimal glands Müller’s muscles orbital vessels
Pupillary light reflexes
• Pupil diameter is subject to continuous variations as a function of changes in luminance, fixation and psychosensitive stimuli.

• Pupils must be studied by evaluating their size, shape, symmetry and activity (dilation and constriction).

• To evaluate size and symmetry of pupils, patients are invited to fixate a faraway object, which must not be a source of excessive light stimulation.
Subsequently, by illuminating the patients’ face from below with a weak light source, both pupils are simultaneously observed and their diameters are determined (mm).

In the normal population, pupil diameter tends to be smaller in children, in the elderly and in subjects with dark iris.
In general, anisocoria which changes with changes of luminance conditions must be considered pathologic, while anisocoria which remains constant, independently from the degree of luminance and is associated to a symmetrical photomotor reflex, is the expression of physiologic or essential anisocoria.

The photomotor reflex must be evaluated:

- the patient fixates a faraway object, to inhibit the near reflex, and each pupil is stimulated by using a high intensity light.
- In the presence of a pupil which scarcely reacts to the direct light stimulus, the indirect or consensual reflex must be examined, by stimulating the contralateral eye.
• If the reflex arc is intact, the direct reflex must be equal to the consensual reflex (due to the double decussation of the pupillary fibers).

• The amplitude, latency and speed of pupil constriction after a light stimulus are generally correlated to the visual acuity of the patient, except in cases in which the visual defect is secondary to a circumscribed foveal lesion or a bilateral occipital pathology, in which pupil activity is normal.

The near pupil reflex is analysed by asking the patient to fixate a faraway object and then to fixate a near object positioned in front of the nose.
• Normal visual function is not a necessary requirement to elicit the near reflex.

• The near pupil reflex must be only evaluated in the presence of an abnormal photomotor reflex.

• The dissociation of photomotor and near reflexes indicates the presence of a mesencephalic pathology (Parinaud’s syndrome, Argyll-Robertson’s pupil) or the involvement of postganglionic parasymathetic fibers (Adie’s tonic pupil).
• The double hemidecussation of pupillary fibers at the level of the optic chiasm and mesencephalus guarantees the presence and symmetry of the direct and indirect reflex.

• Even when the afference of an eye is completely deficient, the symmetry of pupil diameters is maintained by the stimuli originating in the contralateral eye and fibers decussating in the brainstem.

• For this reason, in cases of monolateral blindness anisocoria is never present.
Pupillary light reflex: near dissociation in Parinaud's syndrome
In the presence of anisocoria an ophthalmologic examination is fundamental, with particular attention to the biomicroscopic examination of the anterior segment and the measurement of intraocular pressure.

It is also necessary to exclude the presence of ocular motility defects, alterations of eyelid position and activity, and trigeminal dysfunctions (including corneal reflex).
• The presence of a relative afferent pupillary reflex (RAPD) is one of the most important signs in neuroophthalmology as it provides objective evidence of damage to the anterior visual pathways.

• This sign is evident in the presence of an asymmetry in the function of the afferent system of the two eyes.

• Indeed, when light is positioned infront of the healthy eye, both pupils constrict and then slowly dilate; when the light is positioned infront of the affected eye, the constriction is reduced or absent, but the subsequent dilation is immediately evident.
• To correctly search for the presence of a RAPD it is necessary to begin with both pupils in the dark. Each pupil is then rapidly illuminated in an alternating way (for maximum 3 seconds) passing above the nose.

• A monolateral lesion of the optic nerve is practically always associated to a relative afferent defect, while a bilateral lesion only when strongly asymmetrical

• However, a retinal pathology (eg. Large retinal detachment) may also determine the presence of a RAPD. A slight RAPD may be present in some large macular lesions and in cases of amblyopia.

• It is generally not present in acute papilloedema, severe refractive defects, cataract, non-organic visual loss, or cortical lesions.
Relative afferent pupillary defect (RAPD)
Relative afferent pupillary defect (RAPD)
PHYSIOLOGIC ANISOCORIA:

- The most frequent cause of relative difference in pupil diameter.
- Approx. 20% of the general population presents some degree of anisocoria.
- Physiologic or essential anisocoria is generally 0.5 mm, always less than 1 mm.
- The prevalence of anisocoria increases with age, reaching 33% in the population over 60 years of age.
- The difference in pupil diameter in physiologic anisocoria is constant in different conditions of luminance, with a slight tendency to be more evident in darkness.
LESIONS of the MESENCEPHALUS

- Efferent pupillary defects associated to lesions involving the oculomotor nucleus and its bundle in its mesencephalic pathway
- Features: anisocoria (associated to defects of motility and ptosis), and the pupil with greater diameter reacts weakly to light and convergence.

**Argyll Robertson’s pupil:**
- neurosyphilis
- small-sized (<2 mm) and often irregular pupils.
- Near dissociation is present, and pupils show scarce dilation after instillation of mydriatic eyedrops.
- Similar features, for the presence of near dissociation, are present in diabetes (probably due to a peripheral autonomic neuropathy), chronic alcoholism, encephalitis and some degenerative diseases.
**Parinaud’s syndrome, or dorsal mesencephalus syndrome**

- Pupils in medium mydriasis (4-5 mm), round and regular.
- Dissociation between light reflex, which is scarce or absent, and near reflex, which is normal.
- A consequence of:
  Involvement of afferent pupillary fibers at the pretectal level, that is the fibers which, once leaving the visual pathways, direct towards the pretectal nuclei.

Associated to:
- paralysis of the upwards gaze,
- nystagmus (*convergence-retraction*)
- eyelid retraction (Collier’s sign).

**The most frequent causes** of Parinaud’s syndrome are:
- tumors of the pineal gland region,
- Multiple sclerosis, ischaemic lesions and hydrocephalus with ventricular dilation.
Pupillary light reflex: near dissociation in Parinaud's syndrome
Collier's sign
LESIONS OF THE PARASYMPATHETIC SYSTEM

- The paralysis of the 3rd CN determines pupil involvement generally associated to ptosis and paralysis of extraocular muscles.

- The involved pupil is dilated, and anisocoria is greatest in conditions of high luminance.

- The mydriatic pupil does not react after instillation of low concentrations of cholinergic substances (pilocarpine diluted to 0.125%), while it constricts after normal potency miotic drugs such as 1% pilocarpine.

Pupil dilation may be the only sign of oculomotor nerve paralysis in two extremely rare clinical conditions:

- Uncus herniation
- basal meningitis (tuberculosis, sarcoidosis, syphilis, cryptococcosis).
• The presence of pupil involvement and incomplete paralysis of the oculomotor nerves in subjects with less than 50 years of age must lead to hypothesize the presence of an aneurism in the junction between internal carotid artery and posterior communicating artery. (MRI and, if negative, complete brain angiography).

• In aberrant regenerations of the 3rd CN, especially if post-traumatic, a paradoxal innervation of the pupil sphyncter may be observed, with sectorial contraction during abduction.
• The presence of mydriasis may be of traumatic origin.
• A contusive trauma may in fact damage the sphincter muscle, and in these cases, the presence of lacerations of the pupil edge and defects of transillumination of the iris may be observed. Immediately after trauma, the pupil may be miotic, but changes to medium mydriasis early on, demonstrating a weak reaction to light.

• The monolateral instillation, accidental or voluntary, of mydriatic drugs (such as atropin) may be the cause of anisocoria (pharmacological anisocoria). In these cases the dilated pupil weakly reacts to light and to the near reflex.
Adie’s tonic pupil

- Pathology with unknown etiology, which determines pupil alterations probably secondary to damage at the level of postganglion fibers.
- As the fibers innervating both the pupillary sphincter muscle and the ciliary muscle are involved, both pupil reflexes and accommodation are compromised.
- The pathology is characterized by an irregular and dilated pupil, with scarce or absent reaction to light. Often associated to hypo-areflexia.
Adie's pupil
LESIONS OF THE SYMPATHETIC SYSTEM

*Horner’s syndrome:* Interruption of the ocular sympathetic system during its pathway. Characterized by: miosis, slight ptosis, …enophthalmus
Acquired Horner's syndrome
Congenital Horner's syndrome