Asymmetry of Pupillomotor Input

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Galen of Pergamon, in the second century AD, found the reactivity of the pupils to be clinically useful when deciding whether a cataractous lens should be pushed aside. He tested the pupils by covering one eye and looking for the resulting normal dilation of the uncovered pupil. Even today, if no hand light is available, the pupillomotor input of the two eyes can be readily compared by having the patient look at the sky or at any bright scene and repeatedly covering and uncovering one eye and then doing the same thing with the other eye. The eye in which this manoeuvre produces the greater amplitude of pupillary movement will be the eye with the better optic nerve function. It seems that Galen did not take this step of deliberately comparing the two eyes, nor did he take the next step which would have been to move the cover back and forth from one eye to the other. It is easy to imagine what would happen with an alternating cover if one eye were blind: as the cover was moved from the blind eye to the seeing eye, the patient would suddenly be thrown into darkness and both pupils would dilate, although, of course, only one eye would be visible. Thus the pupil of the blind eye would be seen to dilate when exposed to light and the pupil of the good eye would constrict when exposed to light. In cases with only a subtle asymmetry there would be a slightly stronger initial constriction of the pupil when the good eye was exposed to light and a slight tendency for the pupils to escape from constriction and settle at a wider diameter when the bad eye was illuminated. This is, of course, 'the swinging light test',

except that we now do it in a dark room with a hand light instead of at a window looking out over the Aegean Sea. Galen came very close to it 18 centuries ago. The only reason the alternating light test is preferred today is because the march of technology has put a bright hand light in every doctor's pocket and made it difficult to find a window.

During the European Dark Ages, Arabian philosophers concluded that it was light reaching the eye that made the pupils move and remarked that when light fell on one eye, not only did the pupil of that eye constrict, but the pupil of the opposite eye also contracted 'in consensus'; that is, in accord, or in sympathy, or in agreement with the illuminated eye. Over the years the word 'consensual' has caused a lot of confusion. When reading someone else's description of pupillary activity it is sometimes hard to be sure whether the 'consensual reaction of the right eye' means the constriction of the left pupil when the right eye is stimulated, or the constriction of the right pupil when the left eye is stimulated. Despite this potential for confusion, most of us learned that the way to distinguish a poor light reaction due to a blind eye from a poor light reaction due to a denervated iris sphincter was to look not only at the pupil of the stimulated eye but also at the consensual reaction; that is, at the reactivity of the pupil of the blind eye when the other eye is stimulated. If the poorly reacting pupil of the blind eye is capable of a strong contraction when the pupillomotor input comes via the unaffected eye, then there is nothing wrong with the brainstem neural outflow to the blind eye or

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with the ability of its sphincter to move; and therefore the problem must be an input defect—something wrong with the retina or optic nerve of the blind eye. Of course just seeing that the pupils stay more or less equal in darkness and in light is a good clue that there is no unilateral efferent problem.

Checking for a Relative Afferent Pupillary Defect

A. The Advantages of Alternating the Light

1. *Consensual Dilation.* When, in a dark room, the light is moved quickly from the good eye to the bad eye, one sees a relatively weak pupillary constriction for two reasons:

- (a) there is less pupillomotor input from the bad eye,
- (b) the sphincter now has to overcome the tendency of the pupils to dilate because the light has just been taken away from the good eye.

Thus the direct contraction of the pupil in the second eye is *automatically* subtracted from the consensual dilation which occurs when the first eye is thrown into darkness. This not only increases the difference between the responses of the two eyes, but it simplifies the test. It is now only necessary to watch the illuminated eye. There is no need to work out a way to watch the consensual reaction of the second eye while the first eye is being stimulated.

2. *Pseudo-anisocoria.* When the examining light shines on the eye with the better vision the pupils come down to a smaller size than when the light is on the bad eye. This means that when the examining light leaves the bad eye, crosses the nose and strikes the good eye, more light reaches the retina because at that moment the pupils are bigger. This strengthens the light reaction when the good eye is stimulated, and weakens the light reaction slightly when the bad eye is stimulated. Once again, the quick alternation of the stimulus light amplifies small differences between the two eyes.

3. *Proximity.* Just having one light reaction follow close on the tail of the other makes comparison easier.

4. *Ease of Recording.* A great advantage of the alternating light test is the ease with which the results can be recorded. Either an input

difference is present or it is not, and it is obvious which eye is the impaired one. There is no need for a lengthy and potentially confusing description of the pupil examination.

5. *Quantification is possible.* Any quick and sensitive way to note pupillomotor input asymmetry makes it possible to measure the difference between the eyes by titrating it to a null point with neutral density filters placed over the good eye.

B. Measuring the Relative Afferent Pupillary Defect

1. The Setting

The patient is seated comfortably in a dimly lit or darkened room (the darkness increases the amplitude of the pupillary response to light). The patient is asked to look into the distance and to keep both eyes wide open. The examiner should be comfortable and should be able to see the pupils clearly. It is easier to make decisions about pupil reactions when the irises are of a light colour and the pupils are large. Older patients with small pupils are more difficult to assess because of the small amplitude of the iris movements.

2. The Tools

- (a) Reading glasses or suitable bifocals, if necessary.
- (b) A bright handlight with an even beam and no filament shadow: for example, a fibre-optic transilluminator with a fresh bulb and fresh batteries.
- (c) A set of neutral density filters: for example, photographic quality neutral density filters, 52 mm, screw mount, 0.3 log, 0.6 log, 0.9 log, 1.2 log. These are often available through local photo supply stores.
- (d) A plastic pupil gauge in 0.5 mm steps.

3. The Procedure

- (a) *Check for an impaired light reaction.* If either pupil consistently reacts poorly to light ('an output defect'), then all observations should be made in the eye with the better light reaction.
- (b) *Check for an anisocoria.* Small pupils allow less light into the eye, and large pupils let in more. If neither pupil is smaller than 3 mm in light, then small and

moderate anisocorias (less than 1.0 mm in light) may be disregarded—at least with respect to an afferent defect induced by the pupillary inequality.

- (c) *Start alternating the light* from one eye to the other at a steady rate. Keep the light just below the visual axis and a constant distance from the eye (about two inches); illuminate each eye for about one full second and then switch the light quickly to the other eye.
- (d) *Observe the illuminated eye.* If the pupils react relatively weakly when one eye is stimulated and better when the other is stimulated, then an afferent defect relative to the good eye or a 'relative afferent pupil defect' (RAPD) has been identified. This pupillomotor input asymmetry can be measured by reducing the stimulus intensity to the better eye until both eyes have matched light reactions.
- (e) *Balance the responses.* This is done by holding a filter up over the good eye and repeating the alternating light test. If the RAPD is still visible, increase the density of the filter over the good eye until both eyes are balanced. Deliberately overshoot the balance point and then return to it to be certain of your measurement.

4. Problems

- (a) *The Problem of Retinal Bleach.* Remember that shining more light in one eye than in the other will unbalance the retinal bleach and make one retina more light sensitive than the other. This can be a source of error. There is a strong tendency to continue alternating the light because of a residual doubt in the examiner's mind about the location of the end point. This tends to dull the sensitivity of the retina in the eye with the relative input defect—because it is not shaded by a filter. The best way to overcome this source of asymmetry is to keep both retinas more or less constantly light adapted: (a) every time the filter is changed shine the light for two or three swings on both retinas without any filters in place; (b) when using filters of less than 1.0 log unit make up your mind in five swings or less; for filters over 1.0 log do it in three swings

or less. If a decision has not been made in three swings, take the filter away and shine the light in both eyes to even up the retinal bleach and try again.

- (b) *'Tilting' the Dubious RAPD.* If a very small asymmetry is suspected, e.g. a defect of less than 0.3 log in the left eye, but the examiner is not sure whether he is just seeing noise in the system ('hippus'), an effort can be made to confirm the asymmetry by 'tilting' the RAPD to the right and to the left with a 0.3 log filter. A 0.3 log filter over the suspected left eye would increase a 0.2 log RAPD to 0.5 log units—an easily visible asymmetry of response; whereas the same filter over the right eye would overbalance the input asymmetry and result in a negligible defect (0.1 log) in the other direction. This difference in behaviour when the filter is over different eyes suggests that the RAPD is real.
- (c) *Only One Working Pupil.* When the input defect is in an eye with an injured iris or a dilated pupil, attention will be on the uninjured eye. The direct and consensual responses of the working pupil can still be compared by alternating the light from one eye to the other. While a measurement is being made, the good eye is behind the filter and it may be hard to see the pupil. Sometimes it is necessary to use a side light on the good iris in order to see its consensual pupil reaction. In some instances an infra-red sensitive video camera is used.

The procedure described is not the only way to estimate pupillomotor input asymmetry. We are, in fact, not doing it quite the same way today that we did it a few years ago,¹ and in the future someone may show us a better way to do it.

C. The Value of a Measured Relative Afferent Pupillary Defect

When measuring a RAPD a number is put on the amount of pupillomotor input asymmetry, and this provides a benchmark for comparisons at future visits—a number that is closely correlated to the amount of visual field loss. In a neuro-ophthalmology clinic the RAPD is in constant use. Here are some rules of thumb:

In optic neuritis

Most patients with recovered optic neuritis still have a clear RAPD (more than 0.3 log units) in the affected eye even though the Snellen visual acuity is excellent.

In optic nerve compression

The RAPD is a valuable indicator of progression or recovery of optic nerve damage.

In macular disease

If the visual acuity is no worse than 20/200 do not expect a RAPD of more than 0.5 log units. It's hard to get a RAPD greater than 1.0 log with a lesion confined to the macula. Central serous maculopathy produces very little RAPD: at first as much as 0.3 log, but when the subretinal fluid disappears, so does the RAPD.

In retinal detachment

Each quadrant of fresh, bullous retinal detachment produces about 0.3 log of RAPD, and when the macula comes off, the RAPD jumps up by roughly 0.7 log units.

In anisocoria

The eye with the smaller pupil has a relatively shaded retina, and when less light strikes one retina during the alternating light test it can look like a RAPD. The asymmetry becomes significant when one pupil is very small or when the anisocoria approaches 2 mm.

In suppression amblyopia

A small RAPD in an amblyopic eye should be expected. It is not always there, but if you look carefully it can be seen about 50% of the time. It is generally less than 0.5 log units, and the number does not correlate well with the visual acuity.

In cataracts

A unilateral cataract, even when very dense and pigmented, produces little or no RAPD.

A white, opaque unilateral cataract usually causes excess retinal stimulation by scattering the light, so that there appears to be a RAPD in the other eye—the one with a clear lens.²

In tract lesions

A complete optic tract lesion usually produces a modest RAPD (0.4–0.6 log) in the contralateral eye—the eye with the temporal field loss.

In pretectal lesions

A unilateral lesion in the pretectal nucleus or in the brachium of the superior colliculus (due to an AVM or to a pinealoma) will damage the pupillary fibres coming from the ipsilateral optic tract. This can produce a contralateral RAPD without any loss of visual field.³

In functional visual loss

—there is no RAPD.

Measuring pupillomotor input asymmetry is not a difficult skill to learn; it is easier than mastering the slit lamp, the indirect ophthalmoscope or the streak retinoscope and it is an effective way of teaching residents to pay attention to small asymmetries of pupillary input. If you plan to wait for an instrument to come along to make this measurement for you, you may have a long wait, and furthermore, when it does arrive you will have no personal means of validating the machine's readings.

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