oral vitamin supplementation.⁸ When the remarkable rise in gastric bypass surgical procedures is considered across the world, the realisation of a potential epidemic syndrome of iatrogenic vitamin A deficiency becomes an alarming reality. It is essential that eye care professionals not only recognise and appropriately treat this new syndrome with vitamin A supplements, either the oral (preferably liquid) or intramuscular routes, but also provide education to our colleagues in other fields of medicine to ensure appropriate counselling and early recognition in the hope of preventing this potential epidemic syndrome of gastric bypass surgery and iatrogenic blindness.

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Brain damage in children

Visual problems as a result of brain damage in children

G N Dutton, E C A McKillop, S Saidkasimova

Affected children include those with cerebral palsy, who may or may not have learning difficulties, and those with profound brain damage causing cerebral blindness

Damage to the brain is the commonest cause of visual impairment in children in developed countries.¹ Improved survival of premature infants has increased the prevalence of periventricular leucomalacia, and greater success in managing profoundly ill children has led to increased survival of children with meningitis, encephalitis, and hypoxic ischaemic encephalopathy. Hydrocephalus is now also successfully treated, while congenital disorders of the brain add to the prevalence of brain dysfunction.² On the other hand, early treatment of cataract, the successful management of glaucoma, screening for retinoblastoma, and effective immunisation for rubella have all decreased the prevalence of blindness in children as a result of eye disorders.

A large proportion of the brain serves visual function. The cerebral cortex, underlying white matter, and (during early visual development) the basal ganglia³ all play a major part. The classic view is that the visual system comprises the anterior visual pathways, the lateral geniculate bodies, the optic radiations, and the occipital cortices wherein the process of "vision" takes place. Disruption of these pathways may result in restricted

visual fields and impairment in visual acuity. The article by Lowery *et al* in this issue (p 960)⁴ highlights the importance of having a high index of suspicion when a child presents with undiagnosed poor visual function. Cerebral (or cortical) visual impairment may well be the cause.

In addition to unexplained impairment of visual acuity in a child, what features can lead the clinician to suspect that there is brain damage affecting the visual system? In our experience there is a range of features (table 1) that may accompany impaired acuities and restricted visual fields, or that may even occur in isolation, in a child with brain damage affecting vision.⁵

Primary visual processing takes place in the striate cortex. The analysis of motion takes place more anteriorly. Impaired ability to discriminate the movement characteristics of different animals has recently been shown to be a sensitive marker for periventricular leucomalacia affecting vision.⁶

The fusiform gyri of the inferior temporal lobes, on both sides, ostensibly act as an image store for the panoply of imagery encountered. If the incoming data from the occipital lobes match what is already known, recognition

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takes place; if not, the new information is learned from. This visual pathway is known as the ventral stream. A child with cerebral visual impairment and good acuities may mistake a stranger for a parent, if the ventral stream is dysfunctional. Another function of the ventral stream is orientation and navigation. Children with ventral stream dysfunction can easily become lost.⁷

The posterior parietal lobes and the accompanying dorsal stream pathways from the occipital lobes serve a number of fundamental visual functions. The *British Journal of Ophthalmology* of 1918 contains two seminal articles by Holmes.^{8,9} The first delineates the structure of the visual pathways by relating the location of discreet shrapnel wounds to the resultant visual field loss. The second highlights the functions of the posterior parietal lobes by giving clear descriptions of the visual features resulting from bilateral damage. The affected soldiers had lower visual field loss. They could only attend to (and therefore see) one or two items in their visual scene, and despite having intact stereopsis in a number of cases, they were all unable to use vision to guide movement.

The functions of the dorsal stream pathways comprise the analysis of the complexity of the visual scene, the ability to accord selective visual attention to specific elements, the ability to suppress other elements so that they do not distract, and the handling of other incoming data such as hearing and touch. The dorsal stream also serves the function of determining the visual coordinates of the elements within the visual scene. This informs the motor cortex to facilitate visually guided movement of the body, and the frontal eye fields to bring about rapid eye movement to view the object of interest. Disorder of this complex process is commonly seen, in

Table 1 Outline of some of the clinical features indicative of dorsal and ventral stream dysfunction in children (which can manifest in almost any combination and degree, both in children with no physical impairment and in those with cerebral palsy), with recommendations that can assist the child

Features	Recommendations
Dorsal stream dysfunction	
<i>Impaired ability to handle complex visual scenes* can cause difficulties with:</i>	
Finding a toy in a toy box.	Store toys separately.
Finding an object on a patterned background.	Use plain carpets, bedspreads and decoration.
Finding an item of clothing in a pile of clothes.	Store clothes separately in clear compartments.
Seeing a distant object (despite adequate acuity).	Get close. Share a zoom video/digital camera view.
Identifying someone in a group.	Identify through waving and speaking.
Tendency to get lost in crowded locations.	Training in seeking and identifying landmarks.
Distress in busy shops and crowded places	Visit shops when they are quiet.
Reading.	Determine whether masking surrounding text improves reading ability.
<i>Impaired visually guided movement (optic ataxia)</i>	
Upper limbs: Inaccurate visually guided reach that may be compensated for by reaching beyond an object then gathering it up.	Occupational therapy training.
Lower limbs: Feeling with the foot for the height of the ground ahead at floor boundaries. Difficulty walking over uneven surfaces (Despite full visual field, and looking down.)	Provision of tactile guides to the height of the ground ahead. For example pushing a toy pram or holding on to the belt pocket or elbow of an accompanying person.
<i>Impaired attention</i>	
Difficulty "seeing" when talking at the same time, which may cause a child to trip or bump into obstacles.	Limit conversation when walking.
Marked frustration at being distracted.	Limit distraction by reducing background clutter and background activity. (Performance may be enhanced at the "quiet table" at school.)
Ventral stream dysfunction	
<i>Impaired recognition</i>	
Difficulty recognising people and photographs.	Family and friends introduce themselves and wear consistent identifiers. Training to identify and recognise identifiers.
Difficulty recognising shapes and objects.	Training in tactile recognition as well as visual.
<i>Impaired orientation</i>	
Tendency to easily get lost in known locations.	Training in orientation.

*The difficulties handling complex visual scenes can vary considerably in combination and degree.

varying combinations and degree, in children who have sustained damage in this area of the brain.^{5 10 11}

Other elements, which need to be considered, comprise accommodation and ocular movements. Reduced accommodative function is seen in a large proportion of children with cerebral palsy.¹² This impairs learning and requires dynamic retinoscopy to make the diagnosis, followed by the prescription of a full hypermetropic correction (even for 1 dioptre or 2 dioptres). Some children benefit from a reading add.¹³ Impaired eye movements include strabismus, nystagmus (which is a common accompaniment of periventricular leukomalacia), dystonic eye movements, and disorders of pursuit and saccades.¹⁴ All can interfere with visual function.

Affected children include those with cerebral palsy, who may or may not have learning difficulties, and those with profound brain damage causing cerebral blindness. However, there is also a large group with minimal intellectual dysfunction and normal limb movements who have damage to the posterior part of the brain.⁵ They may only have impaired visual acuities and visual fields, as

described by Lowery *et al*, or they commonly have super-added cognitive visual dysfunction. There is also a group who may have cognitive visual dysfunction with normal or slightly reduced acuities. Such children are at risk of "falling through the net" and being ascribed an incorrect diagnosis, because at present the symptom complexes outlined in table 1 may go unrecognised.

Educational material needs to afford maximum facility of access for all children with cerebral visual impairment. Text and pictures need to be of optimal size and spacing. "Decluttering" of the visual environment, combined with occupational and physiotherapeutic training for optic ataxia, help children with dorsal stream dysfunction, and training that circumvents ventral stream dysfunction (often using methodologies for the blind) can improve both education and behaviour.

Cryptic cerebral visual impairment in children not only includes reduced visual acuities, and impaired visual fields but it can also include cognitive visual dysfunction. When a parent says "My child does not seem to recognise me and cannot find a toy in the toy box

or on a patterned bedspread, and she walks into lamp posts and off the end of pavements," this may well mean that there is cerebral visual impairment due to ventral and dorsal stream dysfunction. This requires assessment and specific measures to help the child.

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The terms cortical and cerebral visual impairment are currently employed interchangeably in the literature. Lowery *et al* have chosen to use the term cortical visual impairment. However, as this review concerns impaired vision caused by damage to brain tissue in addition to the cortex, the term cerebral visual impairment has been chosen.

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