AMBLYOPIA
A New Perspective for an Old Problem

An Essay

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LIST OF ABBREVIATIONS

AAO	American Academy of Ophthalmology
ARC	Anomalous Retinal Correspondence
ATS	Amblyopia Treatment Study
D	Diopters
Hz	Hertz
ICO	International Council of Ophthalmology
IOL	Intra Ocular Lens
JAAPOS	Journal of American Association of Pediatric Ophthalmology & Strabismus
LGN	Lateral Geniculate Nucleus
LogMAR	Logarithm of Minimal Angle Resolution
MOTAS	Monitored Occlusion Treatment for Amblyopia Study
OCT	Optical Coherence Tomography
OKN	Opto Kinetic Nystagmus
P. ERG	Pattern Electroretinogram
P. VEP	Pattern Visual Evoked Potential
PD	Prism Diopters
PEDIG	Pediatric Eye Disease Investigator Group
RCT	Randomized Controlled Study
RNFL	Retinal Nerve Fibre Layer
ROTAS	Randomized Occlusion Treatment for Amblyopia Study
rTMS	Repetitive Transcranial Magnetic Stimulation
VER	Visual Evoked Response
WHO	World Health Organization

INTRODUCTION

The purpose of this essay is to summarize the current concepts and recent literature regarding the pathogenesis, clinical picture, and treatment of amblyopia, in light of evolving pharmacologic, surgical and optical approaches to this prevalent cause of vision loss.

The control of blindness in children is considered a high priority within the World Health Organization's (WHO’s) VISION 2020 – The Right to Sight program. There are several reasons for this. Firstly, children who are born blind or who become blind and survive have a lifetime of blindness ahead of them, with all the associated emotional, social and economic costs to the child, the family and society. Indeed, the number of “blind years” due to all causes of blindness in children is almost equal to the number of “blind years” due to cataract in adults. Secondly, many of the causes of blindness in children are either preventable or treatable. Thirdly, many of the conditions associated with blindness in children are also causes of child mortality (e.g. premature birth, measles, congenital rubella syndrome, vitamin A deficiency, and meningitis). Control of blindness in children is, therefore, closely linked to child survival.

Reducing visual loss in children poses particular challenges which are different from the challenges of controlling adult blindness. Children are born with an immature visual system and, for normal visual development to occur, they need clear, focused images to be transmitted to the higher visual centres. Failure of normal visual maturation (amblyopia) cannot be successfully corrected in adult life, so here is a level of urgency about treating childhood eye disease which does not necessarily apply to adult conditions. The assessment of vision and examination of the eyes also pose particular difficulties, which require time and experience on the part of the examiner. Furthermore, children’s eyes cannot be considered as a smaller version of adult eyes, because they respond differently to medical and surgical treatment (Gilbert C. & Foster A., 2001).

Taking a solid ground from this worldwide care of preventing blindness and especially in children, special attention has been given to this topic of amblyopia.

Amblyopia is one of the most common causes of childhood blindness and an easily preventable and curable disease if correctly diagnosed and treated.

This table of visual acuity scales has been added at the beginning of this essay as a quick and easy reference.

Table1: Visual Acuity Scales

Visual acuity scales			
Foot	**Metre**	**Decimal**	**LogMAR**
20/200	6/60	0.10	1.00
20/160	6/48	0.13	0.90
20/120	6/36	0.17	0.78
20/100	6/30	0.20	0.70
20/80	6/24	0.25	0.60
20/60	6/18	0.33	0.48
20/50	6/15	0.40	0.40
20/40	6/12	0.50	0.30
20/30	6/9	0.63	0.18
20/25	6/7.5	0.80	0.10
20/20	6/6	1.00	0.00
20/16	6/4.8	1.25	-0.10
20/12	6/3.6	1.67	-0.22
20/10	6/3	2.00	-0.30

Visual acuity is often measured according to the size of letters viewed on a Snellen chart or the size of other symbols, such as Landolt Cs or Tumbling E.

In some countries, acuity is expressed as a vulgar fraction, and in some as a decimal number.

Using the foot as a unit of measurement, (fractional) visual acuity is expressed relative to 20/20. Otherwise, using the metre, visual acuity is expressed relative to 6/6. For all intents and purposes, 6/6 vision is equivalent to 20/20. In the decimal system, the acuity is defined as the reciprocal value of the size of the gap (measured in arc minutes) of the smallest Landolt C that can be reliably identified. A value of 1.0 is equal to 20/20.

LogMAR is another commonly used scale which is expressed as the logarithm of the minimum angle of resolution. LogMAR scale converts the geometric sequence of a traditional chart to a linear scale. It measures visual acuity loss; positive values indicate vision loss, while negative values denote normal or better visual acuity. This scale is rarely used clinically; it is more frequently used in statistical calculations because it provides a more scientific equivalent for the traditional clinical statement of “lines lost” or “lines gained”, which is valid only when all steps between lines are equal, which is not usually the case.

DEFINITION OF AMBLYOPIA

As betrayed by its Greek roots, the term amblyopia means blunt or dull vision and is used to describe reduced acuity in usually one but occasionally both eyes that remain after correction of any coexisting refractive condition and which cannot be attributed to a disease. (Mitchell D. E. & Sengpiel F., 2009)

Amblyopia affects approximately three per cent of the population and carries a projected lifetime risk of visual loss of at least 1.2 per cent. (Webber, Ann L. & Wood, Joanne M., 2005)

Unless it is successfully treated in early childhood, amblyopia usually persists into adulthood, and is the most common cause of monocular visual impairment among children and young and middle-aged adults (National Eye Institute Website).

Children are susceptible to amblyopia between birth and 7 years of age (Keech RV & Kutschke PJ, 1995). The earlier the onset of abnormal stimulation, the greater is the visual deficit. The critical period for visual development is somewhat controversial but probably ranges from 1 week to 3 months of age.

For practical purposes, amblyopia is defined as at least 2 Snellen lines difference in visual acuity between the eyes, but amblyopia is truly a spectrum of visual loss, ranging from missing a few letters on the 20/20 line to hand motion vision (Wright, K. et al, 2006).

PATHOPHYSIOLOGY OF AMBLYOPIA

Physiology of vision

Vision is one of the special senses of our sensory system. It follows the same as any sensation in regards of having a receptor, sensory nerves and sensory area in the cerebral cortex for perceiving the sensation. The sensation of vision results from light stimulation of the retinal photoreceptors. This stimulation initiates an action potential that is transmitted along the optic nerve fibres to the visual cortex.

Natural patterned early visual input is essential for the normal development of the central visual pathways and the visual capacities they sustain. Without visual input, the functional development of the visual system stalls not far from the state at birth, and input is distorted or biased the visual system develops in an abnormal fashion result in specific visual deficits (Mitchell D. E. & Sengpiel F., 2009).

Neuro-physiological background of vision is the analysis of a 2 dimension pattern of light falling on the retina by different mechanisms; these mechanisms are present in infants and are later on modified with the development of visual acuity and binocular vision. The infants' vision is characterized by low grating resolution and by low contrast sensitivity.

Growth of the visual system develops through certain changes at different levels. At the level of the eye certain anatomical changes take place:

1- Increase in the length of the cones outer segments which subsequently increases the number of photons captured and this will lead to an increase in their sensitivity.

2- Migration of the cones towards the fovea.

3- Decrease of the inter-cone spacing.

4- Elongation and enlargement of the eye.

A very important thing was noticed, that in amblyopic eyes, no disturbance of these changes occurred, which lead to the conclusion that the eye maintains normal development and that the lesions are at a higher level. (Yuodelis and Hendrickson, 1986)

A period of synaptogenesis occurs at the level of the striate cortex up to the age of nine years forming an elastic period in which the changes and developments occurring are liable to be inhibited.

1) Stereopsis:

It is now well known that depth perception is a function of postnatal age. Stereopsis onset begins abruptly by the age of 3-5 months, usually in females 4 weeks earlier than males.

2) Binocular rivalry:

At the first three months of life, infants do not alternately suppress each eye but instead the eye work by superimposing images, at the age of 3 months rivalry begins leading to the beginning of binocular fusion, then from 3- 6 months there is rapid progress coping with that of stereopsis.

These changes coincide with the staging of binocular functions:

1- Simultaneous perception:

This is the ability of both eyes to perceive the same target object.

2- Fusion of binocular images:

Into one image in the visual cortex

3- Stereopsis:

This is the ability to use horizontal binocular disparity clues to perceive a 3-dimentional image.