بسم الله الرحمن الرحيم

University of Khartoum

Faculty of Medicine

Postgraduate Medical Studies Board

STUDY OF CAUSES AND PREVALENCE OF AMBLYOPIA EX-ANOPSIA IN KHARTOUM EYE TEACHING HOSPITAL

By

Dr. Nagwa Khalid Hamad

MB.BS. (Cairo University)

A thesis submitted in partial fulfillment for the requirements of The Degree of Clinical M.D. in Ophthalmic Surgery and Medicine.

1997

Supervisor
Dr. Mohamed Al-Mustafa Al-Sarrag
MB.BS, (Belgrade),
D.O. (London)

بسم الله الرحمن الرحيم

" وما أوتيتم من العلم إلا قليلا "

صدق الله العظيم

Tables of Contents

Dedication

To the Memory of My Father

To My Family

ABSTRACT

Amblyopia or sometimes-called “lazy eye” is a poor vision in an eye that did not develop normal vision during early childhood. The best

time to correct amblyopia is to detect it early by screening methods and treat it during infancy or early childhood.

This study was carried out in Khartoum Eye Teaching Hospital (K.E.T.H) in the period from October 1996 to December 1997. Data was collected in a period of four months from 1st of January 1997 – 30th of April 1997. A total number of 3000 patients with defective vision were traced from the retraction department. Out of this number 200 were found to be amblyopic, while the remaining number were patients with refractive errors correctable with glasses or other means of correction. Out of the 200, 50 patients showed diseases of the retina and optic nerve (organic amblyopia), while 150 were patients with amblyopia exanopsia.

The objective of this study is to detect the prevalence of amblyopia exanopsia and its different causes among patients attending K.E.T.H, which will reflect roughly the percentage of amblyopia ex-anopsia among Sudanese patients. Amblyopia was found in 5% of the total number in this current study. Males (51.3%) were more affected than females (45.7%). The majority of amblyopic patients (54.6%) were found in the age group from 16-30 years; followed by the age group 5-15 years and this is considered a late presentation.

Younger age groups are not included in this study because very young children are not brought to the hospital by their parents for visual assessment; so amblyopia is not studied in this age group. Unilateral

amblyopia was common in our patients (85.3%) than bilateral amblyopia (14.7%). Also left-sided amblyopes were 52.8% while right-sided were 42.2%.

In this study the leading cause of amblyopia ex-anopsia was anisometropia (46.3%), anisohypermetropia (54.2%) being more than anisomyopia (45.8%). A combination of anisometropia and strabismus was detected in a considerable number of patients. The next common cause is strabismus (27%), esotropia seen in 90% of strabismic patients while exotropia (10%). Strabismus represents the leading cause of amblyopia at the age group from 5-15 years (63.6%).

Regarding the high refractive errors as a third cause of amblyopia ex-anopsia the majority of patients were astigmatic (56.25%), next comes high myopia (31.25%) which is also the main cause of bilateral amblyopia and lastly high hypermetropia (12.5%).

Stimulus deprivation amblyopia group had the least number of patients with a percentage of 5.3% and we believe that these patients are brought late by their parents seeking medical advise and greater number is expected to be seen if survey studies are done.

ملخص الأطروحة

العيون الخاملة (الكسولة) هي العين التي يتطور فيها الإبصار خلال فترة الطفولة الأولى بطريقة طبيعية يعتبر الوقت الأمثل لاكتشاف حالات العين الخاملة عن طريق إجراء المسوحات في وقت الطفولة المبكر .

أجريت هذه الدراسة في مستشفي العيون التعليمي بالخرطوم في الفترة من أكتوبر 1996م حتى ديسمبر 1997م حيث تم معاينة العيون 3000 حالة من المرضي الذين يعانون من ضعف الإبصار وخطأ الانكسار في الفترة من أول 30 أبريل 1997م .–يناير 1997م

كان الغرض من هذه الدراسة هو تحديد النسبة العامة للمرضي الذين يعانون من حالة العين الخاملة الوظيفي والأسباب المختلفة التي تؤدي لحدوث هذه الحالة من بين المرضي الذين يترددون علي مستشفي العيون التعليمي . وجد أن نسبة حالات العين الخاملة تقدر ب 5% من مجموع المرضي . ولقد وجد في هذه الدراسة أن نسبة الذكور 3ر51% ونسبة الإناث 7ر45% . في هذه الدراسة أيضا وجد أن اغلب هذه الحالات وجدت بين عمر 16-30 سنه وهو يعتبر 15 سنه . –حضور متأخر ، تليها مجموعة المرضي الذين تتراوح أعمارهم من 5 أما الأطفال في عمر المدرسة أو ما دون ذلك لم يخضعوا لهذه الدراسة لان هذه الحالات في هذه السن المبكرة تكتشف عن طريق المسوحات ولان ذوي هؤلاء الأطفال لم يحضروهم لمستشفي العيون لإجراء أي تقييم للإبصار .

وجدنا إن نسبة حدوث العين الخاملة التي تصيب عين واحدة هي 3ر85% في حين أن إصابة العينين 7ر14% وان العين اليسرى تأثرت بنسبة 8ر57% والعين اليمني بنسبة 2ر42% .

في حالة الدراسة وجدنا أيضا أن السبب الرئيسي للعين الخاملة الوظيفي هو أخطاء الانكسار المتباينة ، حيث أن نسبتها كانت 3ر46% . أما أخطاء الانكسار المتباينة مع وجود الحول وجد أن عدد ليس بقليل من المرضي من العدد الكلي (3000) مريض وجدنا أن عدد المرضي الذين يعانون من العين الخاملة 200 مريض منهم 150 مريض يعانون من حالة العين الخاملة الوظيفي و 50 مريض يعانون من العين الخاملة العضوي (أمراض الشبكية والعصب البصري) . أما باقي

العدد فكان يعاني من حالات أخطاء الانكسار والتي يمكن تصحيحها عـن طريـق النظارات الطبية أو العدسات اللاصقة . وجدنا إن السبب الثاني لهذه الظـاهرة هـو الحول حيث تمثلت نسبة حدوثه 27% وبالطبع كان الحول الداخلي اكثر تسببا مـن 15 سنه (6ر63%).–الحول الخارجي وكانت نسبة حدوثه في السن المبكرة من 5

أما حالات أخطاء الانكسار العالية الدرجة المتسببة في حدوث خمول العين الوظيفي كانت هي أخطاء الانكسار في المحور الواحد 25ر56% تليها حالات قصر النظر العالية الدرجة 25ر31% والذي هو أيضا سبب في حدوث حـالات العـين الخاملة في العينين ، ثم يأتي طول النظر في المرتبة الأخيرة 5ر12%.

حالات العين الخاملة بسبب حرمان المؤثر هي الأقل عددا والمتمثلة نسبتها في 3ر5% . وباعتقادنا أن سبب قلة هذا العدد هو عدم إحضـار الأطفـال للعنايـة الطبية في المستشفي في وقت مبكر . ويتوقع أن يكون هذا العدد اكبر مـن ذلـك اذا أجريت المسوحات الميدانية .

In the name of God the Merciful the Compassionate

Proforma

Study of causes and prevalence of Amblyopia ex-anopsia in KFTH

Name: ---------- Age ---------- Sex ----------

Residence ---------- Occupation ---------- Ser. Nol.------

C/O

Present history:-

- Onset and duration ----------

Past history :-

- P.H. of glasses ----------

- P.H. of systemic diseases ----------
--
- P.H. of drugs ----------
--
- P.H. of ocular diseases ----------
--
- Trauma ----------
--

Family history:-

- Of hereditory ocular diseases ----------
--
- Refractive errors ----------
--
- Strabismus ----------
--

Birth history:-

- Abnormality during pregnancy ----------
- Abnormality of delivery ----------
--
- Fevers during childhood ----------
--
- Vaccination during childhood ----------
--

Bad habits:-

- Alcoholism ----------

- Tobacco ----------

- Cannabis ----------

Previous treatment:-

- Optical since when ----------

- Surgical ----------

- Orthoptic: occlusion ----------

Exercise ----------

Ophthalmic examination:-

V.A.

Aided (contact lens-glasses)

Unaided

	Rt eye	Lt eye
Lids		
Lac. Apparatus		
Conj.		
Cornea		
A/C		
Pupil		
Iris		
Lens		
I.O.P.		
Fundus reflex		
Fundus Ex.		

Refraction & Accessory Investigations:-

Orthoptic Examination:-

C.T.----------

O.M. ----------

M.W.T.----------

M.R.T.----------

P.B.C.T. ----------
S.P. ----------
Fusion ----------
S.V. ----------

Cause of Amblyopia

Acknowledgment

Before all, I thank almighty God for helping me to complete this dissertation, I would like to express my appreciation to Dr. Mohamed El Mustafa Al Sarrag, Ophthalmic surgeon at Khartoum Eye Teaching Hospital for supervising this thesis, for his guidance and encouragement while conducting this study.

My thanks are extended to all my colleagues who helped me In the orthoptic and refraction departments.

Finally my thanks to my brother Alaa Eldin Khalid Hamad for his efforts to bring this thesis in its present form.

Chapter One

Introduction AND Literature Review

The word amblyopia is derived from the Greek word amblus means blunt and the stem ops: means vision thus meaning "blunted vision 'or' dullness of vision" [1]. Amblyopia is one of the most important causes of visual loss in the world; affecting 2 to 6 of every 100 people in the U.S.A. and representing a leading cause of impaired vision in childhood and young adults[2]. The word amblyopia ex-anopsia means weak vision on a functional basis, and it can strongly be a hereditary condition[2,3].

Ambloypia ex-anopsia is an example of abnormal visual development that is clinically defined as a reduction of best corrected Snellen's acuity to less than 6/9 (20/30) in one eye or a two line difference between the two eyes with no visible signs of eye disease[5]. Also amblyopia exanopsia is defined as acquired defect in vision due to abnormal experience during a sensitive period of visual development. However, in modern times it has acquired a specific meaning, it is defined as a unilateral or bilateral

decrease of visual acuity caused by form vision deprivation and/or abnormal binocular interaction[6]. Von Grafe also defined amblyopia as the condition in which the observer sees nothing and the patient very little[7]. This situation prevails in spite of the fact that amblyopia, is in principle, preventable or in appropriate cases treatable, and is reversible by the therapeutic measures[3,8], loss of vision may be so mild that it is difficult to detect clinically or so severe, but light perception is always preserved.

Although our understanding of amblyopia has improved greatly over the past thirty years and much has been learned about the physiological basis of amblyopia yet it remains a major and a difficult challenge to clinicians. If detected early with screening programs, the prognosis for successful treatment is greatly increased. If missed; the child may suffer from a life time of poor vision in one eye. Children who fail a visual screening test should be promptly referred to an ophthalmologist. Prompt detection and treatment of amblyopia secure a child the best chance for a good visual outcome[9].

Risk factors for functional amblyopia are strabismus, spherical equivalent of the refractive error of 3.5 dioptres or more anisometropia of 1.0 dioptre or more. Among the risk factors are heredity, failure to emmetropize, and high hyperopia at the age of one year[10,11]. Strabismus is a significant cause of ocular morbidity leading to amblyopia and psychosocial distress in childhood and adulthood[2]. Abnormalities of the optical media or alignment of the eyes during the period of visual immaturity may produce pathological changes in the brain resulting in the clinical entity of subnormal vision known as amblyopia.

Efforts to prevent visual deterioration or restore normal acuity where amblyopia exists require early diagnosis & treatment. Although amblyopia affects mainly children, it is estimated that at most 1/4 of pre-school children are screened for this major treatable eye disease. Primary strabismus may lead to loss of vision from amblyopia and loss of binocularity. Secondary strabismus may be a sign of primary visual loss in one or both eyes

and the most serious disorder that may present as secondary strabismus is retinoblastoma.

Amblyopia is detected by assessing the visual acuity of each eye, strabismus is detected by using the corneal light reflex test and the cover test. Focusing problems are detected by assessing the visual acuity and the red reflex. Cataracts and retinoblastoma may be detected by assessing the red reflex of the eye.

Treatment of amblyopia ex-anopsia consists of correcting the amblyogenic factors with appropriate glasses and surgery. The preferred eye is patched with an adhesive patch to stimulate visual development in the amblyopic eye[12].

Tobacco amblyopia as another variety of amblyopia (organic amblyopia) was once an important cause of bilateral optic neuropathy. It has been so rare that some investigators doubt its existence. Tobacco amblyopia can develop even without malnutrition, alcoholism or disordered vitamin B12 metabolism.

Patients recover with cessation of smoking and with intramuscular administration of hydroxycobalamine despite

continued smoking[13]. Among the causes of organic amblyopia is x-chromosomal retinoschisis. Seventy percent (70%) of the ametropic group were unaware of their visual defect which can lead to the development of amblyopia, this is of importance, because the longer the treatment for amblyopia is delayed, the lower the chance of complete recovery[14].

Variables in amblyopia classification and quantitative definition differences, timing of presentation, non equivalent treatment comparisons, and compliance variability have been uncontrolled in virtually all extent studies of amblyopia treatment outcome.

This makes if difficult or impossible to evaluate either the relative efficacy or different treatment regimens for amblyopia or the effects of age on treatment outcome within the pre-school age group. Existence of such an age effect is the primary rationale for screening at younger rather than older pre-school ages[15].

For many years amblyopia was considered to be a retinal disorder. It has been well established through animal studies that

amblyopia represents functional and morphological effects on the visual cortex and lateral geniculate nucleus. With this knowledge has come the recognition of a sensitive period of development of the visual system during which time visual deprivation causes amblyopia. The best approach for managing amblyopia is to detect amblyogenic factors (risk factors) before the age of two years and prevent it through eliminating the causes of visual deprivation.

When amblyopia exists, it can be cured if adequately treated in children less than 6-7 years of age where the visual system is immature and plastic. Vulnerability is greatest during the first few months of life and decreases gradually thereafter. Even in old patients, visual improvement can be achieved with appropriate and long-term therapy[3].

History of Amblyopia:

A description of treating amblyopia and strabismus since the 16th century was mentioned in literature, and over such a long period of time, there have been trends of resorting to certain methods, e.g. Bangester and Cupper's penalization.

As long as (1722) Saint Yves described occlusion of the dominant eye to promote use of the squinting eye. Buffoon (1743) recommended occlusion of the good eye to straighten the squinting one. Erasums Darwin grand father of Charles Darwin gave a much more comprehensive on account of treating strabismus; by placing a piece of gauze stretched on a circle of whale-bone, to cover the best eye in such a manner as to reduce the distinctness of vision of this eye to a similar degree of imperfection with the other and this should be worn some hours every day. Or the better eye should be totally darkened by a tin cup covered with black silk for some hours daily, by which means the better eye will be gradually weakened by the want of use, and the worse eye will be gradually strengthened by using it.

Others, such as Doners (1864) blamed habitual suppression for the loss of vision. Priestly – Smith (1898) considered that highly amblyopic eyes, squint earlier than others just because they are amblyopic.

In the 9th century some workers considered amblyopia as congenital and it is cause of any associated strabismus.

Javal in France and Worth in England in the late 19th century were powerful advocates of correcting refractive errors and using occlusion for amblyopia. They also originally used atropine to fog the fixing eye and encourage near fixation by the amblyopic eye.

Miss Sheila Mayou in (1934) adopted a new method in which she starts treatment with consistent and total occlusion, lessening the size and opacity of the occluder as the vision improves.

Bangester showed that an amblyopic eye could fixate with a none foveolar area. He introduced "pleoptics" meaning "full or more" vision, where he attempted functional destruction of eccentric fixation by intense dazzling or blinding light. This was followed by elaborate methods of stimulation of the fovea.

Hubel and Wiesel (1962) showed that in a kitten which is monocularly deprived by a lid suture during immaturity not only is the deprived eye apparently almost blind but the function of neurons in the visual cortex is also grossly abnormal.

Blackmore and Cooper (1970) demonstrated the interesting phenomenon of meridional amblyopia in kitten.

Ideda and Wright (1972) showed that the central ganglion cells of the retina in cats required a sharply focused image in order to respond, while the peripheral ganglion cells on the other hand still respond in a transient fashion if the stimulus spot was defocused by more than 12 diopters.

By carefully occluding one eye after the other, Blackmore and Von Sluyters (1974) showed that an animal monocularly deprived has an equal number of uniiocularly driven neurons; but a reduced number of binocular neurons.

The foundation for current investigation in visual physiology were laid by Hubel and Wiesel in (1960s). And for the last twenty years much have been understood concerning amblyopia and new

data are becoming available almost on a daily basis. However, in view to the remarkable progress in research during recent years, the mystery of amblyopia that has fascinated ophthalmologists for so many years may well become understood in the forseenable future[16].

Prevalence:

The prevalence of amblyopia in humans is estimated to be about 2% - 6% making it a serious world-wide health problem[17]. It is difficult to assess the frequency of amblyopia in the general population. Some rather large-scale studies have been conducted on selected population. The figures range from 2% to 6% among recruited soldiers 0.5% to 3.5% in pre-school and school age children and 4% to 5.3% in patients with ophthalmic problems, therefore, it can be assumed that 2.0% to 2.5% of the general population has amblyopia[18].

The Pathophysiology of Amblyopia:

Our understanding to the physiological basis of amblyopia in humans has undergone dramatic changes over the past two decades. The first change occurred when we were able to record from single neurons in different parts of the visual pathway and develop neural models of the anomaly. The second came from psychophysical investigations and evaluation of these models. Our understanding has progressed from one focused on the properties of single cortical cells to an appreciation of the anomalous behaviour of cellular networks[19].

So to understand the neuronal basis of amblyopia, we have to study the effects of abnormal environmental influences on the genetically programmed development of the visual processing system. Visual pathway development commences with ganglion cells forming the optic nerve. The process that guides these neurons initially to the lateral geniculate nucleus LGN and then onto the visual cortex (V1) is genetically programme, initially this process is influenced by spontaneously generated impulses and

neurotropic factors. Following birth, visual stimuli modify and refine the genetically programmed process.

Exposure to the environment includes the risk of abnormal inputs. Abnormal stimuli disrupt the formation of patterned inputs allowing alteration of visual cortical writing with reduction in ocular dominance columns driven by the abnormal eye[20].

In ambloyopia the visual inputs from the amblyopic eye are suppressed. Many authors have suggested that binocular rivalry is the basis of suppression in amblyopia. Binocular rivalry occurs when both eyes view two images that are so dissimilar that they cannot be fused.

It seems that there are a combination of processes operating to produce suppression in amblyopia, which particular process is operating depends upon the pathogenesis of the amblyopia, the depth of amblyopia, the angle of the strabismus where present, and whether there is the capacity for alternate fixation.

Observers with normal stereopsis suppress some of the monocular information contained in each stereo half – image, a

phenomenon we call fusional suppression, operating to suppress monocular signals in the weaker eye, without affecting the benefits of normal stereopsis and fusion[21].

The difference in contrast sensitivity between the two eyes can lead to suppression, through dichoptic masking in anisometropic amblyopia and small angle strabismus. Dichoptic masking is the physiological process where a stimulus of a given contrast presented to one eye can prevent the detection of a lower contrast but otherwise identical stimulus presented to the other eye. So suppression is disparity dependant in small angle strabismus.

Strabismus of substantial angle invariably precipitates a disturbance or disruption of binocular vision, because the two images of each feature in the visual scene fall on entirely non – corresponding points in the two retinae. Despite the resulting potential for diplopia and confusion, after strabismus of early onset the visual system adapts to the situation, and single vision is maintained, either through anomalous retinal correspondence, in

which functional correspondence is shifted to match the angle of squint, or through a powerful form of binocular rivalry suppression, there is powerful interocular suppression that strabismic human experience.

Cortical neurons tend to fall into two populations of monocularly excitable cells and exhibit suppressive binocular interocular interactions that share key properties with perceptual suppression in strabismic humans.

Such interocular suppression, if prolonged and asymmetric (with input from the squinting eye habitually suppressed by that from the fixating eye) might lead to neural defects in the representation of the deviating eye and hence to amblyopia[22].

The development of acuity in infancy is not solely due to foveal maturation, since there is a clear development of acuity in the peripheral visual field. The development of peripheral acuity, and the naso-temporal asymmetry during early development reinforce the idea that the visual loss in adult strabismic

amblyopes is not due to an arrest of development, but rather to the chronic interocular suppression of the deviated eye.

There exists fundamental difference in the neuronal losses in humans with strabismic and anisometropic amblyopia. The losses in positional acuity of anisometropic amblyopia may be accounted for on the basis of the reduced contrast sensitivity and increased neural pooling of the underlying visual filters, whereas strabismic amblyopia, like the normal periphery, shows an extra loss which may be accounted for on the basis of scrambling, a jitter in the topographic mapping of information from the retina to cortex[23].

In neurons which retain binocularity to adulthood, two different neural mechanisms of adaptation to ocular misalignment exist. Some of these neurons become amblyopic, such that the non – deviating eye dominates the response for high spatial frequencies while the strabismic eye dominates at low spatial frequencies.

Other neurons adapt through active suppression of the monocular response to stimulation of the strabismic eye when the

non-deviating eye is simultaneously stimulated. The profound visual deficits associated with early monocular form deprivation (MD) caused largely by competitive binocular interactions in the visual cortex[24]. Studies show that monocular sensory deficits caused by abnormal early visual experience as a result of bilateral form deprivation are much less severe than those caused by unilateral form deprivation.

The differences in the severity of visual deficits may be attributed to the consequences of anomalous binocular competition associated with unilateral form deprivation that was minimized during bilateral form deprivation. Thus, studies illustrate that anomalous binocular competition is more essential for the developing visual system of infants than direct deprivation per se[21]. Unilateral deprivation in visually mature patients does not affect in the same way visual acuity since once the central connections have been firmly established, the mature visual system is immune to abnormal input.

It appears certain that most of the excitatory synapses in the visual system are cholinergic. On the other hand there appears relatively good evidence that neuronal inhibition within the visual cortex is mediated by the inhibitory neuro-transmitter, gamma-aminobutyric acid-GABA.

GABA ergic neurons in the LGN act as regulators in dealing with and important visual signals towards striate cortex. Previous experiments have shown that early unilateral eye lid suture a model of amblyopia induced by cataract causes shrinkage of ocular dominance columns serving the deprived eye in the striate cortex, also cell shrinkage in monkey's lateral geniculate nucleus LGN layers supplied by the amblyopic eye have been described in experimental amblyopia caused by visual ldeprivation, anisometropia and strabismus.

Significant neuronal cell shrinkage was present in layers connected with the amblyopic eye, and was most evident in the epsilateral LGN. Changes in the brain from a human strabismic amblyope are similar to those previously described in monkeys.

The reduction of the geniculo cortical projection from the deprived eye has been thought to explain in part the mechanism of amblyopia. Some forms of amblyopia can occur without shrinkage of ocular dominance columns. Studies also show that shrinkage of ocular dominance columns does not occur in humans with amblyopia caused by accommodative esotropia, the ocular dominance columns are probably no longer susceptible to shrinkage at the age when most children with this condition begin to develop amblyopia[24-26].

Classification of Amblyopia:

Amblyopia is defined as a reduction in the visual acuity that is due to abnormal visual experiences early in life. This abnormal visual experience consists of insufficient exposure to sharply focused images, which can affect one or both eyes, or a difference in the quality of the inputs from the two eyes to the binocular visual centres in the brain which contribute only to unilateral

amblyopia. So it is an impairment or extinction of an existing function[3].

According to the clinical classification of Von Noorden (1967) amblyopia is classified into:

1) Organic amblyopia:

In which amblyopia is caused by an organic disease and these are more difficult to define and are generally caused by organic pathology such as optic atrophy, macular lesions, neonatal macular haemorrhage; the incidence of which was found higher in vaginal delivery with foetal distress, in mal-orientation of retinal receptors, core dysfunction syndrome and several organic ocular defects which are associated with a relatively irreversible reduction in vision.

Other defects such as congenital nystagmus and albinism are sometimes included in this group. Even when the organic lesion itself is not correctable, the resulting amblyopia may improve sometimes with treatment. Therefore, any child with reduced

vision who has an identifiable retinal or optic nerve lesion should be given a trial of occlusion therapy to treat any amblyopic component[9,27-28].

2) *Functional amblyopia*:

Also known as amblyopia ex-anopsia or disuse amblyopia and it is caused by disuse of the neural connections that maintain their functional integrity only through normal use, in the absence of any organic disease. These are reversible disorders and partial recovery of visual functions with treatment can be obtained. More recently, organic defects have been demonstrated in the visual pathways in experimental animals with induced forms of functional amblyopia which makes adherence to the classification increasingly difficult.

Von Noorden subclassified functional amblyopia into strabismus amblyopia, anisometropic amblyopia and visual deprivation amblyopia. Deprivation of the visual stimulus may be partial as in many forms of refractive errors or total as in congenital cataract. Some authors consider ametropic amblyopia

as a separate sub-group of functional amblyopia. It results usually from marked errors of refraction and marked astigmatism, which is often bilateral, but only one meridian in either eye may be involved, so that it is sometimes called "meridional amblyopia", so according to Von Noorden amblyopia ex-anopsia is classified into:

(1) Strabismic amblyopia:

In the presence of a unilateral squint, although there is light stimulus, there is form deprivation owing to the fact that the fovea of the deviating eye receives an image other than that received by the fovea of the fixing eye. This image will be blurred because (Binocular) accommodation exerted is governed by the requirements of the fixing eye. The most prevalent form of amblyopia is that which is associated with just strabismus or a combination of strabismus and anisometropia and it is seen in patients who strongly favour one ye fixation (a unilateral rather than an alternating pattern).

It is common to find amblyopia in esotropes than in exotropes. This could be related to the nasotemporal asymmetry

of the retinocortical projections. In esotropes; the fovea of the deviating eye has to complete with the strong temporal hemifield of the fellow eye, while in exotropes; the fovea completes with the weaker contralateral nasal hemifield.

Esotropia may be congenital as it presents within the first 6 months of life, and is commonly seen in mentally retarded or brain damaged infants. Refraction is usually normal for the age of the child. Management is essentially surgical and should be preformed prior to age of 16 months, careful follow up surgery as about 40% will subsequently develop amblyopia[29].

Refractive esotropia is due to excessive hypermetropia and here esotropia is controlled completely with spectacles and surgery is not required. If the deviation is not correctable with spectacles then the condition is partially accommodative esotropia.

Early correction of hypermetropia reduces the incidence of esotropia, if esostropia is reduced by prescribing glasses early, the rate of esotropic induced amblyopia can be similarly reduced[30].

Chavasse was the first to suggest the theoretical advantage of early realignment and was supported later by the studies of Costanbader and Tylor[31,32]. It has been reported that performing corrective surgery in children esotropia before full resolution of amblyopia, is safe and efficient if the amblyopia therapy is continued after surgery. It has been reported that 56% of children who had surgery for infantile esotropia in the first 24 weeks of life achieved peripheral fusion following surgery and treatment for amblyopia, 20% remained amblyopic[33,34]. Full time occlusion of the preferred eye is the most effective method when started at the youngest possible age. Ideally, the amblyopia treatment is continued until the fixation alternate freely from one eye to the other in preverbal children or linear Snellen's acuity is 6/6 in each eye.

If no improvement occurs over 3 to 6 months, during which occlusion has been applied. It is appropriate to discontinue primary therapy[35].

Maintenance patching is adopted for children in whom vision improved but fixation does not alternate or Snellen's acuity is not equal in the two eyes at the end of initial course of occlusion. Abrupt cessation of occlusion may result in recurrence, maintenance regimen is used for several months or years to preserve improved vision.

Pleoptics and penalization can also be used in the treatment of esotropic amblyopia. Amblyopia, when with constant exotropia is secondary to previous esotropia, anisometropia or retinal pathology. If amblyopia is present, we should try to treat it and occasionally, improving vision may straighten the eyes. If the amblyopia has not been successfully treated or if the patient is too old for an attempt to amblyopia therapy, surgery should be limited to the amblyopic exotropic eye regardless of the amount of deviation[36].

(2) Anisometropic amblyopia:

The inequality of the refractive errors results in a blurred image in one eye and consequent failure of visual acuity to

develop. Because peripheral fusion is strong there is no manifest squint, so that such cases are frequently not detected until school eye tests take place, by which time very serious central amblyopia may have established[37].

It is a well-known cause of amblyopia even in the absence of strabismus. Strabismus is frequently associated with anisometropia and it is difficult to determine whether the cause of amblyopia is the strabismus, antisometropia or both. In many anisometropic amblyopia a detailed examination will reveal microstrabismus.

As a rule, amblyopia is more common and is higher degree in patients with anisohypermetropia than in those with anisomyopia, although contradictory view have been reported.

This is most likely due to the fact that a myopically defocused eye has the potential to receive some normal stimulation from objects that happen to be nearer than the fixation target, and the more myopic eye can be used for near work and the less myopic for distance. But in the case of some hyperopically

focused eye it will be impossible to receive proper stimulation from a target at any distance[18].

Anisometropic amblyopia may go undetected until late in childhood as many patients do not have strabismus and any course of therapy begins with correcting the underlying refractive error. If amblyopia is mild spontaneous improvement may occur over several weeks or months, with pronounced anisometropia, contact lenses may be preferable to reduce anisokonia.

(3) Ametropic amblyopia:

The corrected visual acuity frequently does not come up to standard, particularly in the higher degrees of the defect.

Broelcema (1909) found that normal acuity 6/6 was obtained in 82% of hypermetropes with an error of 1-2 diopters, in 63.5% of those with an error of 3-4 diopters, in 44% from 5-6 diopters and in only 15% when the error was from 7-10 diopaters. Researches show that the incidence and degree of amblyopia decreased gradually and those of myopia increased along with the growing

up of children in ametropia. In binocular refractive amblyopia, high and medium hyperopia than in mild amblyopia.

In monocular refractive amblyopia, high and medium hyperopia and high myopia in the amblyopic eyes were more than those in the non amblyopic eyes. It is considered that refractive amblyopia is closely related to high ametropia[38].

Poor visual acuity 1/6 of the normal Broelcema found to be rare in the small errors 0.8% and six times more common in the high errors 4.6% when the subnormal vision is bilateral, as is usually the case when the refractive error was not corrected in early childhood (amblyopia of uncorrected ametropia). The acuity usually improves to some extent after wearing correcting spectacles for some months. On the other hand, probably because of the difficulty of acquiring and maintaining good binocular vision inequality of vision in the two eyes is common and unilateral amblyopia is no rare event even in the absence of squint. The same difficulties which favour the development of a convergent accommodative squint are increased when an

inequality of the hypermetropia in the two eyes makes their mutual association more difficult.

Such interocular amblyopia is unfortunately only liable to treatment by occlusion in early life; it is not ordinarily improved by correcting lenses. An unequal degree of high myopia in the two eyes is so common to be almost the rule. The most dramatic form of asymmetry is in the occurrence of unilateral high myopia, in unilateral myopia the affected eye is often amblyopic and eccentric fixation is common, only a small percentage can be expected to attain useful binocular vision with the aid of contact lenses and prolonged pleoptic treatment lasting for periods up to three years.

The corrected visual acuity in high degrees of astigmatism can by no means be brought up to normal standards particularly if the optical correction is not made in early life and also if the astigmatism is oblique. This difficulty is perceptual and there may be a tendency or poor differentiation to be accentuated in the meridian of greatest astigmatism (astigmatic amblyopia).

Amblyopia ex-anopsia affecting all meridian is more common in the higher degrees and there is a tendency for strabismus to develop particularly in the presence of hypermetropic errors. Hypermetropia of 3 diopters or more as well as astigmatism of one or more dioptre at the age of 12 months, especially oblique astigmatism, increase the rate of amblyopia and strabismus until the age of 4 years. The risk rises too, if the refractive error deteriorates[39].

(4) Stimulus deprivation:

This is a condition of reduced visual acuity resulting from interruption of form (foveal) and light (retinal) stimulus following prolonged monocular deprivation during early years of the developmental period.

Stimulus deprivation refers to a total lack of pattern stimulation as a result of uncorrected infantile cataract, corneal opacities, complete ptosis or produced iatrogenically in formerly fixing eye of amblyopic patient by over enthusiastic patching (occlusion amblyopia).

It is relatively rare clinical problem accounting for no more than 3% of cases of amblopyia[11]. The unilateral form is usually more severe, and often accompanied by secondary (sensory) esotropia or exotropia. It is important in the treatment of stimulus deprivation amblyopia the removal of barriers to well focused retinal images as soon as possible, preferably within the first 6 weeks of life in case of congenital stimulus deprivation.

In congenital cataract, surgery must be followed by contact lens correction of aphakia and initiation of occlusion of normal eye for half the working hours or more and to be maintained at least until school age.

If congenital unilateral cataract is untreated till the age of 4 to 6 months visual rehabilitation is so small. In a case report by Sinskey, Amin and Lingira from California; a cataract extraction and primary capsulotomy with intraocular lens (IOL) implantation was performed on a 17-day infant with a monocular mature congenital cataract. The IOL power, calculated at the time of surgery, was undercorrected to compensate for the growth of the

eye ball. Two additional surgical procedures were required to resolve visual axis obstruction caused by lens epithelial cell proliferation. Follow up was 18 months, during which amblyopia prevention therapy was instituted[40].

It is also observed that even the eyes operated on very early in new borns aged a few days, remained often amblyopic[41]. It is also observed that optical correction of the resulting aphakia, usually with contact lenses, and long term treatment of amblyopia when required are invariably more difficult[42].

Penetrating eye injuries remain an important cause of blindness among children, and an important cause of amblyopia due to corneal opacities or traumatic cataracts. Young children with penetrating eye injuries requiring only primary repair may achieve excellent visual recovery, whereas those with traumatic cataract necessitating lensectomy and vitreous surgery have a less favourable outcome because of more severe injury and subsequent amblyopia[24].

Children older than 3 years of age rarely tolerate contact lenses for unilateral surgical aphakia. This problem is even more pronounced following repair of corneal lacerations or perforations that are associated with traumatic cataracts. Even if surgery is successful such eyes are functionally doomed because of deep anisometropic amblyopia[43].

Children with severe, unilateral congenital ptosis are at risk of developing amblyopia if the lid obscures the visual axis. In this situation urgent repair of the ptosis is indicated. These patients generally have very poor levator function and a brow suspension surgery is required. The suspensory material which gives the best long-term results is autogenous fascia lata, or otherwise 4/0 prolene as a temporary suspensory material[44].

Patients with unilateral congenital ptosis often adopt chin elevation to maintain fusion. This compensatory head posture has been considered a sign of fusion, thus indicating a low risk for amblyopia. So compensatory head posture allows peripheral fusion even when significant amblyopia is present.

Additionally, the clinical sign of a compensatory head turn to maintain binocular vision does not rule out the presence of significant amblyopia[45]. Amblyopia was detected in 19% of patients with congenital ptosis in a study done by Hornblass, Kass and Ziffer. A correlation between severe non-occlusive ptosis (greater than or equal to 4mm) and the development of anisometropia was identified. So early surgery for severe non-occlusive congenital ptosis may reduce the incidence of amblyopia[46].

***3) Suppression amblyopia*:**

The disuse in turn is a consequence of suppression which interrupts the normal flow of impulses. In suppression whether in reference to the eye or to any other sense receptor. It is characteristic that when the subject ceases to suppress the sense organ is at once ready for use, with no loss of efficiency.

When amblyopia is present, however, the sense organ does not operate at full efficiency even when the subject has ceased to suppress.

This poor performance might due to a defect in the receptor itself, in the nervous pathways, or even in the higher centres[47,48].

4) Toxic amblyopia:

This condition typically affects heavy drinkers and pipe smokers who have a diet deficient in protein and B vitamin[27]. In recent years the investigation of patients with certain types of toxic amblyopia in particular tobacco amblyopia, has revealed a number of underlying biochemical abnormalities.

There is considerable evidence to support the theory that chronic cyanide toxicity and inability to detoxicate this radically may be the underlying abnormalities in patients with tobacco amblyopia, and possibly in some other types of optic neuropathy[49].

In 1991 to 1994 epidemic of neuropathy in cuba has been one of the more devastating in recent history affecting more than 50,000 people through-out the entire country with clinical manifestations of optic and peripheral neuropathy. Although the

causes are not entirely clear, it seems that a combination of acute nutritional deficiency and toxic effects of tobacco are involved[50].

These mechanisms by which cyanide may induce demyelination in the optic nerve are not clear, although a possible interference with choline synthesis can be postulated. What does seem certain is that tobacco amblyopia, and presumably some of the other toxic amblyopias are of multifactorial aetiology in which exposure to cyanide, low dietary intake of protein, a low intake of vitamin B12, a defective absorption of vitamin B12 and other factors not as yet identified all play a part. Cyanide gas inhalation at a low concentration was proved to be harmful to the optic nerve under condition of B12 deficiency, but other toxic elements such as nicotine and carbon monoxide may be important factors to cause severe changes in the optic nerve with an abnormal VEP response[51].

As regards to the treatment of tobacco amblyopia, a good response is obtained from high doses of hyddroxycobalamine 5mg daily for two weeks followed by 1 mg daily for two weeks

followed by 1 mg three times weekly until visual improvement is complete or by giving oral cystine 4-8 mg daily or by insisting on the cessation of smoking[49].

It is mentioned in literature that folate deficiency should be considered in any patient with progressive bilateral optic neuropathy of unknown aetiology. Treatment with folic acid can result in significant improvement in visual function[52].

5) Idiopathic amblyopia:

This type of amblyopia is seen in the absence of usual amblyopiogenic conditions and in apparently normal patients with a negative history of strabismus. It is an infrequently occurring type of amblyopia and diagnosis is by exclusion. By patching the sound eye visual acuity improves in the amblyopic eye, but the amblyopia reoccurs when the treatment is suspended. Clinically these patients have foveal suppression of the amblyopic eye and it has been postulated that binocularly provoked inhibition has been conditioned during infancy by an amblyopiogenic factor, such as

transient anisometropia that persists even though the original obstacle to bifoveal fusion is no longer evident[18,35].

6) Amblyopia secondary to Nystagmus:

Nystagmus may account for reduced visual acuity in its latent and manifest form and, it is difficult to determine whether nystagmus is the cause or effect of reduced vision. Therefore in the differential diagnosis of bilateral amblyopia, it is helpful to observe the fixation behaviour in each eye during examination.

When micronystagmus is present, horizontal to and fro oscillations of the eye can be observed and they consist of a quick and a slow phase and are different from the irregular jerky fixation pattern in the strabismic amblyopia or the pendular slow frequency nystagmus in blind patients[18].

In spasmus nutans which is a condition that includes asymmetric nystagmus and occurs during the amblyogenic period, there was a significantly higher incidence of strabismus and amblyopia of the eye with the greater amplitude of nystagmus. Most of patients with spasmus nutans require spectacles for

improvement in visual acuity and for treatment of amblyopia. Early detection and treatment of anticipated abnormal visual issues in patients with spasmus nutans will optimize visual outcome[53].

The Clinical and Psychophysical Features of Amblyopia:

1) Immaturity of the Visual System:

Binocular single vision is the co-ordinate use of the two eyes in order to produce a single mental impression. In its widest sense the term merely implies the simultaneous use of both eyes, each contributing to a common perception, but if the binocular single vision is said to be normal there must be a bifoveal fixation. It therefore depends on the satisfactory structural development of both eyes and is achieved only if their actions are linked by strong bonds.

At birth neither of these basic requirements is fully developed and thus refined binocular single vision is not attainable by the infant. But under normal circumstances it will

become established during the first few years of life. There are those who consider binocular development is a maturing of innate binocular ability while others believe that it is entirely a learned function. To whichever school one belongs, it can certainly be said that the foundations for the development of the binocular vision are laid before birth and reinforced by time and usage. In recent years there has been much research into binocular development in infancy in an attempt to establish the "critical age" before which lies the sensitive period[37].

Critical age is that age after which the sensory adaptations to disordered binocular vision especially amblyopia are difficult to occur.

Conversely there is clinical and experimental evidence that there is a period of particular sensitivity to sensory change probably from the age of few weeks to about six months. It is difficult to determine the age beyond which sensory changes are unlikely to occur. It is possible that this is at about the age of 4-5 years.

The late figure of 9 years which has been put forward probably refers to the latest time at which a relapse may occur in patients who have already developed sensory anomalies.

In a study done by Keech – RV and Kutschke – PJ on the upper age limit for the development of amblyopia[28], they concluded that no patient developed amblyopia after 73 months (6.1 years) of age, and that, the age of the patient when exposed to an amblyopia – inducing condition is the most important determinant for the development of amblyopia. Patients 6 years or older with a normal visual system have low probability of developing amblyopia following the onset of amblyopia – inducing condition[5,48]. The precise cut off age of treat ability of amblyopia cannot be established with certainly and is probably less clear established than the age of susceptibility[54]. Infants and young children rapidly suffer severe visual loss when subjected to amblyopia – inducing condition such as strabismus, anisometropia or optical media opacities.

Older children are also vulnerable to the development of amblyopia when exposed to the same precipitating factors, although the time required for amblyopia to develop is longer and the severity of the amblyopia is less when compared with the condition in young children.

Only two reports in the literature that addressed this topic. Von Noorden estimated the upper age limit for the development of amblyopia to be 5.75 years, while Veegan and Taylor found that children are vulnerable to the onset of amblyopia until at least the age of 10 years. Neither report provided statistical analysis. Greenwald and Parks attribute the development of amblyopia to a failure to use the foveo-cortical system adequately during the labile period which they define as the first decade of life[48].

2) Visual Acuity:

Amblyopia always reduces visual acuity and the visual performance of an amblyopic eye is impaired whether or not the other eye is viewing a similar scene. The visual defect is more complex than a simple acuity measurement would indicate. An

amblyopic person can easily distinguish between the quality of vision in his amblyopic eye and that produced by reduction of acuity in his non amblyopic eye to the same level by blurring with lenses or by acquired organic lesion. It has been shown that the development of acuity in infancy is not solely a foveal maturation, since there is a clear development of acuity in the peripheral visual field[55]. In this respect, amblyopia differs fundamentally from suppression and anomalous retinal correspondence, which are detectable only during binocular viewing.

Amblyopia also unlike these adaptations of binocular vision in that it does not serve the useful purpose of eliminating diplopia. Precise characterization of amblyopic vision is not easy, however, a great deal of variation occurs among amblyopes, the sources of which are often not apparent.

Detailed laboratory investigations are restricted to small numbers of adult subjects. Findings are critically dependant on the exact condition of testing, which are usually far remote from those of everyday seeing. Consequently, controversy still

surrounds many aspects of this subject. The following items emphasize features of amblyopic vision that are important to clinicians or may reveal something about the pathophysiology of amblyopia.

a) The crowding phenomenon:

The crowding effect, defined as the ratio of visual acuities for letters presented in Snellen's (i.e. line) format and isolated letter format[56]. In amblyopia visual acuity for single letters (optotype) on a uniform background is better, usually to a considerable degree than the visual acuity for a line of letters. This crowding phenomenon is important in assessing not only the degree of amblyopia but also the response to treatment.

Visual acuity is a result of a highly complex process involving not only the ability of the eye to distinguish objects as separate (angular acuity) but also to process that information, integrating the other features of the visual field in the light of experience (morphoscopic acuity).

Crowding has been thought to be the result of various factors such as the conflict between abnormal localization which has followed the development of a squint, and the persistence of some degree of normal localization, so that the visual cortex receives simultaneous and superimposed information from normal and abnormal retinal points.

This is the most likely explanation, but it may be related also to the presence of a scotoma at the fixation point which is denser than the central scotoma. However, even in the normal eye resolution of an object is influenced by adjacent contours, the form.

Flom, Weymouth and Kahneman (1963) have shown that the interaction between acuity targets and adjacent contours is merely greater in amblyopes and not basically different. In the treatment of amblyopia the disappearance of crowding, as shown by equal line and single letter acuity may indicate a more stable cure. In the normal fovea, contour interaction occurs when forms are separated by distance of 1-3 minutes of arc, in the normal periphery its extent is much greater.

Other conditions that reduce acuity produce a similar extension of contour interaction. What appears to be unique to amblyopia is the magnitude of the decrease in resolution that may result. Occasionally an amblyopic eye that can resolve a 20/20 (6/6) letter in isolation drops as low as 20/100 (6/24) in the presence of maximal contour interaction. Amblyopia cannot be considered cured until linear Snellen's acuity has become normal.

Contour interaction is related to two other features of visual processing. Spatial summation and lateral inhibition. Spatial Summation refers to the reduction in the brightness required for the detection of a small spot of light as its area is increased.

Lateral inhibition is observed when the threshold for detection of a small test object is increased by illumination of the surrounding retina. Like contour interaction spatial summation and lateral inhibition occur over very short distances in the normal fovea (about 3 minutes of arc for spatial summation and 10 minutes of arc for lateral inhibition) and greater distances in the normal periphery[3].

b) Visual acuity of amblyopic eyes under monocular and binocular conditions:

Visual acuity of amblyopic eyes in patients with esotropia, exotropia and hypermetropic and myopic anisometropia was determined monocularly and when the sound eye was open but prevented from seeing the test letters with a phase difference haploscope. A decrement of visual acuity in the amblyopic eye under binocular conditions occurred most frequently in esotropes and hypermetropic anisometropes and less frequently (50%) in exotropes and myopic anisometropes.

This phenomenon, was not observed with reduced visual acuity caused by organic macular lesions. The test has a diagnostic value in differentiating functional from organic amblyopia, and it may have prognostic significance in predicting the response of therapy[57].

c) Grating and contrast sensitivity:

patterns of alternating light and dark strips known as grating, have been used extensively to anlayse form vision in recent years. Their application to the study of amblyopia has led to a number of interesting observations.

A grating pattern is characterized by:

1. The orientation of its strips.
2. Its spatial frequency (the number of light dark pairs or circles per degree of visual angle).
3. The degree of contrast between its light and dark elements.

A square-wave grating consists of uniform light and dark strips with sharp edges. A sinusoidal grating has a sine-wave luminance profile with gradual transitions from light to dark. Sinusoidal gratings are particularly important and widely used in vision research because any complex luminance profile can be resolved into sine-wave components of different frequency by the mathematical technique of Fourier analysis. The highest spatial frequency at which the strips in a grating can be resolved with

maximum contrast is called the "cut-off frequency" or "grating acuity".

For normal human eye, there is 30-40 cycles per degree (for both square-wave and sinusoidal gratings) comparable to the minimum separation of elements required for recognition of conventional optotypes[3].

Grating acuity is usually reduced in amblyopia, but often by less than Snellen's acuity. i.e. grating acuity does not worsen proportionately with poorer letter visual acuity[58]. Some amblyopes even have normal grating acuities. Although they have no difficulty detecting the presence of a grating pattern near the cut-off frequency, they report that they observe marked distortion of the strips. This distortion of spatial relationships appears to be highly characteristic of amblyopic vision[3].

Retinal visual acuity (grating acuity) in 84% of the normal eyes was the same as E – acuity (recognition acuity), while in 66% of the amblyopic eyes, specially the strabismic category, retinal

visual acuity was not affected by the orientation of the grating or the size of the light field.

Grating of different orientations can be used to study meridional variation in acuity. Reduction in grating acuity that is limited to the more ametropic meridians can be demonstrated in markedly astigmatic persons wearing full optical correction. This phenomenon known as "meridional amblyopia" is difficult to detect with conventional measurement of acuity. It is presumably due to lack of correction for refractive error during the critical early years of life. Meridional amblyopia resulting from refractive error may be either unilateral or bilateral or bilateral. Some strabismic amblyopes (esotropes and exotropes) who do not have significant astigmatism have greater reduction in acuity for vertical gratings than horizontal gratings. This is thought to reflect the greater impact of horizonatal image displacement in the deviating eye on cortical neurons selective for vertical orientation[3]. The visual system can respond to sinusoidal gratings over a broad range of spatial frequencies below the acuity

cut-off. At different frequencies different amounts of contrast are required for the detection of the grating pattern.

Plotting contrast sensitivity (the reciprocal of threshold contrast) against spatial frequency yields a curve called the contrast sensitivity function (CSF). Normally contrast sensitivity peaks, at about 3 cycles per degree and falls off gradually at lower frequencies. Contrast sensitivity at low frequencies is very important to form vision.

The low frequencies carry information about the shape and position of large objects. While high frequency components define lines, edges, and fine details. Visual acuity whether measured with grating or optotypes reflects high frequency performance only[3].

The important of the contrast sensitivity functions (CSF) derives from its ability to reveal and quantitates low frequency losses. When CSFs were used to evaluate amblyopia, losses in the CSF were discovered in both the amblyopic and the non-amblyopic eyes. During occlusion therapy the amblyopic eye

improved in acuity and CSF and the non-amblyopic eye improved in CSF only. So it has been suggested that the non-amblyopic eye is not normal and that the CSF provides additional information to acuity about amblyopia in children and that amblyopic eye influence contrast sensitivity (CS) in dominant eye through interocular interactions. This process may serve to minimize CSF differences between the eyes and maximize binocular vision[55,56].

The investigations of CS in amblyopia by Hess and associates has shown that two classes of amblyopes can be defined. In one, CS is reduced at high spatial frequencies only; while in the other sensitivity is reduced at low as well as at high frequencies only. Reduction in acuity is unrelated to the presence of low spatial frequency losses. Low frequency loss has been found more often in anisometropic than strabismic amblyopes, who show normalization of the visual function at low contrast.

There is severe low frequency loss which seems to be a constant feature of amblyopia resulting from cataracts[3,56].

Also CS of amblyopes is reduced by relatively similar amounts to that of normal subjects when noise is added to the stimulus. So the overall; masking effects are virtually identical for amblyopia and for subjects with normal binocular vision[59]. CS deficits were similar for luminance and colour stimuli in normal and amblyopic visual systems. In the majority of amblyopic subjects, however, the deficits in positional acuity were greater for the chromatic than the luminance stimuli[60].

Electro physiological studies in animals have shown that high and low spatial frequencies are handled quite differently by the visual system. In the retina and the lateral geniculate nucleus LGN; there are distinct classes of cells (designated X and Y) that seem to be specialized for processing the high and low frequency components of visual input. The recognition that some amblyopes have reduced low frequency sensitivity while others do not, suggests that more than one physiological mechanism may be responsible for amblyopia.

d) Visual acuity testing:

The definitive method for form acuity is to evaluate the patient's ability to discern increasingly small symbols. Visual acuity testing can be direct or indirect.

Direct Testing:

a) ***Snellen's test type****:*

The Snellen's letters, illiterate E's and landolt's C are standard for measuring visual acuity for adults and older children. Intelligent and well adjusted children of approximately 4 years of age are willing to perform a subjective testing of the acuity. The optotypes are graded according to the angle they project at the nodal point of the eye. A line of symbols should always be offered to the patients, rather than just one symbol in order to detect crowding phenomenon[37].

b) Pictures:

Pictures are another symbol available for illiterates. They are intended to project angles at the nodal point, equivalent to the Snellen's symbols of comparable size; however their varied shapes

do not permit the same accuracy. The picture method should be reserved for those patients unable to be tested with the Snellen's illiterate E method. The picture material a problem for some young children either because they have no personal experience with the article pictured or because they are unable to recall the noun. Those features are non-existent in the Snellen's illiterate E test[37]. Home – vision test, which uses picture cards of familiar figures, proved to be efficient and inexpensive. A test of visual acuity for young children that is more sensitive to amblyopia than current pre-school vision test is modified "Allen pictures". It induces a contour interaction similar to that of line letter test and thus, a more sensitive test of amblyopia than isolated symbols[6].

Indirect testing:

By testing the fixation reflex some conclusions may be made regarding visual acuity.

a) Cover-uncover test:

Can reveal much even when there is no obvious manifest squint, but the test must be done deftly and rapidly before

attention is lost. It should be performed with easily interchangeable series of small attractive fixation targets and the test is conducted with a firm and friendly covering hand rather than alarming occluder. The examiners' thumb is probably the best substitute. Infants and children should be seated on the parents lap for this examination[37].

b) Optokinetic nystagmus:

Used as an indication of the threshold of good vision. It can be excited by horizontal movement of striped ribbons or scarves and by rotating striped drums of various designs. A similar effect can be induced by the catford drum, which is perhaps the most convenient instrument for this purpose. A gradually reduced size of steadily moving target can be presented first binocularly and then monocularly so that, with expertise it is possible to establish the degree of near visual response for each eye. Target comprising a horizontal black line 5 minutes thick offset by 1 minute were printed on strips to stick to the drum of the catford visual acuity apparatus. The vernier targets so produced correspond to the

different sizes of the Snellen's letters from 6/6 to 2/60 when presented at 50 cms[37].

Vernier acuity:

Vernier acuity refers to the ability to detect small misalignments between adjacent objects such as lines or bars. It is a measure of the smallest defectable misalignment in position, expressed in minutes of visual arc. Previous work has established that vernier acuity is larger (i.e. worse) than normal in the amblyopic eyes of adults. However, the magnitude of deficit appears to depend on whether the aetiology of the amblyopia is strabismic or anisometropic. In most patients with anisometropic amblyopia, there is a correlation between deficits in vernier acuity and grating acuity or contrast sensitivity. In strabismic amblyopia, the observed deficits in verier acuity are greater than would be predicted from losses in contrast sensitivity or grating acuity[61].

Stereo-grams:

Stereo-grams discernable only when there is good visual acuity in each eye and good binocular single vision. Measurement of stereopsis is a valuable tool to the clinician when assessing visual development in infant and young children and provides valuable information on binocular status.

Reduction or absence of stereoacuity may be caused by anisometropia, strabismus or amblyopia and the effect of the treatment on these conditions may be monitored by effect on stereo performance. Many clinical stereo tests including TND, random dot E (RDE), small target random dot stereogram (STRDS) and the modified Frisby stereo test are used.

Prefrential looking:

New preferential looking tests has been presented for measuring visual acuity in infants and young children e.g. Cardiff acuity test CAR, Teller's acuity test.

Visuscope:

A more refine objective technique for studying the fixation reflex is to observe the retinal position of the projected target viewed by the patient within an ophthalmoscope beam. The instrument manufactured for this purpose is called the visuscope. This technique admirably confirms grossly eccentric fixation but lacks the sensitivity to absolutely confirm perfect foveal fixation. Visuscope demands that the patient comprehended the direction to fixate and follow the target and that he has the motivation to cooperate. This is not a test applicable to infants, young children and mentally retarded[3].

Photo refraction:

Photoscreening is a photographic method to determine whether a child's eyes focus properly or not. This method can be used from the moment the child is able to fix, which is around six months.

Photoscreening depends on taking a flash photograph of the subject's eye. The light reflected from the retina is analysed to

detect refractive error, strabismus and/or media opacities. This method can be used in mass-screening of siblings, the evaluation of glasses, the monitoring of the effects of occlusion and the post-operative follow-up of patients.

There are two types of photoscreening cameras and flash source. The off-axis system has a flash source slightly off the optical axis of the camera. The on-axis system has a coaxial camera and flash source. Several studies comparing the two systems have found that the off-axis system provides more information with fewer photographs of the corneal and fundus reflex from both eyes. Using off-axis flash photo refractor appears to be practical, efficient and effective method of eye screening in pre-verbal children[62-65].

The photoscreener uses eccentric photo-refraction principles and provide two meridian photographs of the retinal reflex. This new two flash photo-screening camera, which uses high speed Polaroid film, is an accurate reliable method of detecting amblyogenic factors in undilated children[65]. Photoscreening

shows a sensivity of 94% and a specificity of 79%. It also identified some cases of esotropia and refractive error which are missed on clinical examination[38].

Photo-refraction is the most effective objective screening technique for amblyopia risk factors in the preverbal child, because conventional testing is difficult. Photo-refraction screening will become more wide-spread in its use as a screening tool in detecting the early factors responsible and associated with delayed visual maturation in the very young and that hospital departments of medical illustration may love to become conversant with the use of this new tool[66].

Otago photoscreener:

Is an optical instrument which gives a very sensitive indication of the accuracy with which a subject's eyes are fixing and focusing[67].

MTI photoscreener:

(Medical technology incorporation).

The Bruckner's test:

Is used to measure quantitatively the change in the coaxial fundus reflex with varying degrees of ocular misalignment. This technology can be automated to detect the presence of 2 degrees to 3 degrees of ocular misalignment based on the difference in brightness of the bright pupil image between the eyes[68].

Video refractometer VRB 200:

Is a computerized infra-red video refractometer which is a very sensitive device able to recognize amblyogenic refractive error, especially in babies and infants[11].

3) The Visual Field:

Amblyopia affects primarily foveal vision, but demonstration of a central scotoma by conventional means is difficult due to the difficulty that many amblyopes have in maintaining central fixation.

Wald and Burian measured absolute light sensitivity in dark-adapted amblyopic subjects and found no difference from normal

across the visual field. In the dark-adapted state however, both normal and amblyopic eyes show a relative reduction in light sensitivity in the rod-free fovea. When the visual field of an amblyopic eye is plotted in the light-adapted state, a central depression can be demonstrated, but only if very small targets are employed. If larger test spots are used the increased spatial summation of the amblyopic fovea eliminates the scotoma[3].

The degree of visual field damage is in correlation with the degree of visual acuity decrease[69]. The amblyopic visual field has also been mapped with techniques that measure acuity at different retinal loci. The results of these studies confirm that it is primarily the central vision which is defective in amblyopia.

The area of central depression in the visual field tends to be larger in anisometropic amblyopes than in strabismic amblyopes with the same visual acuity. In some strabismic amblyopes, naso-temporal asymmetry of the central field depression has been demonstrated[3]. Both strabismic and anisometropic amblyopes frequently showed deficits of visual sensitivity in the central part

of the visual field, but no systematic deficits in the peripheral field of the amblyopic eyes. Strabismic alternators has practically equal fields in the two eyes[70].

The application of the objectively determined dioptric value leads to normalization of the visual field in amblyopic persons due to hypermetropia, although it does not improve visual acuity. This is an important observation, since extensive visual field failings without the introduction of the objectively determined correction may raise suspicion of a retrobulbar inflammation or atrophy of the optic nerve[2].

Visual field studies are very important in patients with pathological myopia or both diagnostic and prognostic values. Enlargement of the blind spot is a constant finding in myopia. Central and paracentral scotoma has also been found. Bitemporal hemianopia is an interesting finding in pathological myopia and should not be confused with chiasmal tumour[71]. Occasionally the myopic scotomata resemble of the uncorrected and the corrected eye, however, frequently give rise to bizarre scotoma which can be

largely eliminated by the use of the contact lenses (Jayle and Ourgand 1953).

Blott concluded that the changes in the fields in amblyopia where high myopia is present depended more on the depth than on the surface extent of the choroido-retinal lesions[72]. Coeco-central scotoma is the characteristic field defect found in toxic amblyopia.

Severe amblyopia (less than 6/60 20/200 acuity) also affects extrafoveal visual function, and in some cases depression of the visual field all the way to its nasal termination can be demonstrated.

One portion of the field seems always to be spared however, the far temporal periphery, which is monocular. This part of the amblyopic eyes projection to the visual cortex is not subjected to competition from the input of the other eye.

The monocular temporal field is functionally important, and its preservation implies that the total extent of the field of vision is

normal in the most severely amblyopic patients, provided the eyes are straight and there is no media opacity in the amblyopic eye[3].

In suppression amblyopia scotomata can be elicited in the visual field these scotomata can appear or enlarge binocular conditions[73].

4) Effects of Illumination on the Visual Acuity in Amblyopia

As mentioned above the visual field of the amblyopic eye appears normal when plotted with very dim lights following dark adaptation. The difference between normal and amblyopic eyes with respect to other aspects of vision also tends to diminish when illumination is reduced. Von Noorden and Burian found that most amblyopic eyes show little or no reduction in acuity when viewing through neutral density filters, dark enough to reduce the normal eye's acuity substantially. The difference in acuity between normal and amblyopic tends to disappear at low levels of illumination.

In contrast, the visual acuity, of organically diseased eye deteriorates more with reduction in illumination. Recent observations suggest that this characteristics of vision in reduced illumination is more likely to be seen in strabismic than anisometropic amblyopia.

Whether the process of dark adaptation is abnormal in amblyopia remains a matter of dispute. Wald and Burian observed normal dark adaptation in their classic study of amblyopic vision. These observations do not imply abnormality of the rods and cones in amblyopic eyes, since dark adaptation is a complex process involving functional changes in neurons as well as regeneration of visual pigments.

Adjustment to varying illumination does occur at low levels of visual processing, and the effects of illumination on amblyopic vision suggest that there is a subcortical defect in amblyopia[3].

5) Colour Vision in Amblyopia

In contrast to organic disease of the retina or optic nerve, amblyopia typically causes no major disturbance of colour vision.

Wald and Burian demonstrated normal spectral sensitivity in severely amblyopic patients in both the photopic and the scotopic states. Recently subtle abnormalities have been found in the increment threshold spectral sensitivity, which differs from the absolute sensitivity measured by Wald and Burian in that test lights are presented against a brightly illuminated white background.

Like other aspects of amblyopic vision spectral sensitivity seems to be most disturbed at relatively high levels of overall illumination. The abnormality of increment threshold spectral sensitivity has been attributed to abnormal lateral inhibition involving red-green colour opponent cells, possibly at the retinal level. Mild to moderate amblyopia does not affect performance on clinical tests of colour vision, but when acuity is severely reduced (6/60 20/200 or less), errors are common. The mistakes secondary to masked impairment of form vision rather than to a specific defect in colour discrimination.

Colour contrast thresholds are normal in functional amblyopia (with central fixation). Whenever elevated tritan colour contrast threshold are found in patients with a decreased visual acuity, other causes of visual impairment are to be evaluated, recently however blue colour discrimination was significantly worse and the level of the rod threshold significantly higher in high myopic eyes than in normal eyes. The stretching of the posterior pole in high myopic eyes might explain this minimal impairment of the photo receptor layer of the retina[3,48,74].

6) Pupillary Light Reflex in Amblyopia:

Most amblyopic eyes, including those with severely reduced visual acuity, show no clinically detectable abnormality of the pupil, observation of the papillary light reaction is, in fact, one of the most important ways of differentiating amblyopia from optic nerve disease; which typically affects the pupil even when there is minimal reduction in acuity. Pupillo graphic studies have shown, however, that subtle alterations of the papillary light reaction do occur in amblyopia. With careful observation, these can be

detected in about 10% of all amblyopic patients by means of the "swinging flashlight" test for afferent pupillary defects. The pupillary responses generated by an amblyopic eyes seem to be independent of visual acuity mild afferent defects may be seen with 6/18 20/60 vision or better[3]. In recent studies relative afferent papillary defects (RAPD) were detected in 32.3% of patients with amblyopia by a modification of the swinging flashlight test and synoptophore.

The significant factors which were identified in patients showing a RAPD were :

- Anisometropia.
- Early age of onset where strabismus was present.
- Level of visual acuity following treatment.
- Larger period of occlusion therapy.

These points consider the possibility of the causative defect being at ganglion cell level[75]. Also on using contrast modulation of sinusoidal grating (pupil grating response), reductions in response, amplitude and latency were found in anisometropic and

strabismic patients when comparing, the good and the affected eyes, although the observed differences were only significant in the strabismic group[76].

Consequently children with anisocoria (after putting aside other possible reasons; oculr or neurological) should be promptly examined for refraction and visual acuity in order to diagnose anisometropia and to prevent development of amblyopia[77].

The fact that amblyopia can affect the pupil is a strong evidence for the occurrence of the phyisiological abnormality at the retinal level in at least some cases. The lack of correlation between vision and the pupil suggests that the non-retinal component of amblyopia may be the principle cause of reduced acuity[3].

7) Accommodation in Amblyopia:

amblyopia eyes lack the normal ability to the central accommodative mechanism. This is not susrprising, considering that the function of accommodation to bring the retinal images into sharp focus, a state that the amblyopic eye has difficulty

recognizing. When an amblyopic eye attempts to accommodate, the response generally less than that required for sharp focus[3].

There is ample evidence in the literature for a significantly lower accommodative response in the anisometropic amblyopic eye. It has been proposed that the efferent accommodative dysfunction may be fundamental and causative factor in anisometropic amblyopia. In patients with reduced visual acuity for near over that for distance, not only was the final visual outcome poor but also the onset of visual improvement in response to amblyopic therapy was delayed[78].

These observations are relevant to the treatment of amblyopia, the presence of several diopters of hyperopia has no effect on visual acuity in the otherwise normal eye in childhood, but in the amblyopic eye with insufficient accommodation there is a significant refractive blurr at all viewing distances. This blurr may prevent or retard an improvement in vision with occlusion therapy. Thus every amblyopic child with more than 1 or 2

diopters of hyperopia should wear full optical correction during treatment period[3].

8) Fixation in Amblyopia:

Amblyopia is often associated with abnormalities of fixation. Visual experience early in life appears to be critical to the development of the motor centers that direct and maintain fixation, as it is critical to the development of the sensory visual system. Nystagmus typically develops within the first 2 to 3 months of life in any child whose brain fails to receive normal visual input from at least one fovea. This occurs when the foveas are anatomically normal and prevented from functioning by bilateral total cataracts or other dense media opacities or when there is disease or mal-development of the visual system itself.

Severe unilateral amblyopia (visual acuity less than 6/60 20/200) from any cause is associated with unsteady fixation when the non amblyopic eye is covered. Successful treatment of amblyopia results in increased steadiness of fixation with improvement in visual acuity.

Eccentric fixation:

Is another abnormality that is frequently observed in any amblyopic eye, particularly in strabismic amblyopia. A person with eccentric fixation consistently directs a non foveal retinal area towards the object of regard when viewing monocularly with the amblyopic eye. Grossly eccentric fixation is easily detected with the cover test. Often, however, the locus of fixation is displaced from the center of the fovea only by one or two degrees.

In these cases the abnormality will be missed unless the examiner employs a more precise diagnostic technique such as the visuscope or Haidinger's brushes.

With the use of such tests eccentric fixation has been deteced in a majority of all strabismic amblyopes. Esotropes typically fixate on the nasal side of the fovea and exotropes on the temporal side. There may also be a vertical displacement[3,37,27]. Exceptions to this rule are common i.e. paradoxical e.g. temporal in esotropia and sometimes fixations do not have strabismus at all.

The acuity of an eccesntrically fixing eye is never better than the normal acuity of the retinal area used for fixation, but it may be considerably poorer. Severe reduction in acuity may occur in absence of eccentric fixation. Eccentric fixation thus cannot be considered the primary cause of reduced acuity in amblyopia, nor does it account for any of the other features of amblyopic vision. Although it has been the subject of intense study and speculation, the origin of eccentric fixation remains obscure.

It has been claimed that it is caused by anomalous retinal correspondence, but the fact that in many cases the angle of eccentricity is quite different from the angle of anomaly makes this explanation difficult to accept. Another theory holds that the locus of eccentric fixation has the best visual acuity than any other point on the retina of the amblyopic eye. Careful mapping of acuity across the visual field, however, demonstrates that in some cases the fovea retains better vision than the eccentric fixation locus.

A number of other hypotheses have been advanced to explain this curious phenomenon but non can be considered fully satisfactory at present.

Among the most important controversies related to amblyopia has been the question of whether eccentric fixation per se must be corrected by specific treatment to restore normal vision to amblyopic eye. The entire system of pleoptics, was based on the belief that eccentric fixation did require specific therapy. The best evidence currently available, however, indicates that the conventional occlusion therapy alone is as effective in eliminating eccentric fixation as any other regimen[3].

9) Electrical Potentials in Amblyopia

The visual evoked potential VEP:

The VEP is an electrical signal recorded from the occipital region of the scalp in response to visual stimulation of the retina by light. Since most of the external visual cortex is representative of the macular area of the eye, the test is essentially a method of testing macular function. The VEP is the only objective test that

can assess the functional status of the visual system beyond the retinal ganglion cells. For this reason, an abnormal visual evoked response VER suggest an organic lesion in the pathway between and including the ganglion cell layer and the visual cortex.

The VER to a flash of light is a complex wave with great variability. In addition, the responses to various types of stimuli give different information. The type of stimulus sued depends on the purpose of the recording and the type of patient on whom the test is being performed.

The stimulus may be either:

Flash VERs:

Which can be used in assessing retinocortical conduction properties in infants or in-cooperative patients. It gives no information other than the light has been perceived. **OR**

Pattern VERs:

In the normal eye, there is expected increase in VER wave form, amplitude and complexity upon addition of pattern to the stimulus. However, for stimulation of the amblyopic eye, the

introduction of pattern produced a decreased in wave form, amplitude and complexity.

It appeared that the amblyopic eye and its connected visual circuitry were indeed capable of detecting pattern but when pattern was perceived, further visual processing was shut down, resulting in this paradoxic VER reduction. Thus it was postulated that pattern was capable of inducing inhibitory suppression of visual processing in amblyopia and that excessive suppression or inhibition might be a major physiological defect in amblyopia[79]. A pattern check board is consisting of light and dark checks that reverse periodically while maintaining a constant mean luminance.

The VEP is very sensitive to variation in the specific parameters of the visual stimulus and recording technique, and results reported from different laboratories have differed significantly. No consistent abnormality of the flash VEP has been found in amblyopia, but there is general agreement that the VEP

response to pattern stimuli of appropriate dimensions is reduced in amplitude and has a normal or slightly prolonged latency[3].

In patients with amblyopia, the affected pathway had no effect on binocular pattern visual evoked potential latency, suggesting that the amblyopic eye was suppressed. Regardless of the type of amblyopia, the amplitude of the pattern –reversal VEP for full-field stimulation was significantly smaller and the latency significantly longer through the amblyopic eye.

For pattern-reversal VEPs through the amblyopic eyes, the extent to which amplitude was reduced and latency prolonged correlated well with the reduction in visual acuity[80]. Clinically the VEP may be useful in distinguishing amblyopia from optic nerve disease such as retrobulbar neuritis, which markedly prolongs VEP latency or from malingering, in which the VEP is normal.

The amblyopic VEP is not sufficiently distinctive, to differentiate amblyopia reliably from a variety of other conditions; including mild optic nerve hypoplasia and uncorrected optical

blurr. The VEP shows promise as a mean of monitoring the progress of amblyopia therapy in children who are too young for conventional acuity testing but the technical complexity of the method currently limits its clinical application for this purpose[3,81].

In amblyopia, results showed that although the fellow eye of an amblyopic eye or the cured amblyopic eye had normal visual acuity; the VEPs presented abnormal, the marked abnormality being the prolongation of the latency. This demonstrated that possibly the clinical examinations of the visual acuity and VEPs reflect different visual information processes and the normal eyes of amblyopes are not normal[82].

The VEP is generated in the occipital lobes, but it may be affected by an abnormality at any level from the cornea to the cortex. The fact that it is altered in amblyopia does not imply that a cortical disturbance is responsible for amblyopic vision. It is worth noting, however, that the VEP latency is considerably less prolonged than the reaction time (the time required to produce a motor response to a visual stimulus). This suggests that

amblyopia has a defect in visual processing above the level of the primary visual cortex[3].

Electro retinogram (ERG):

Electro-retinogram is an electrical potential produced or generated by the retina in response to light stimulation of an adequate intensity. The recording is made between an active electrode embedded in a contact lens and placed on the cornea, and a reference electrode on the patient's forehead. The potential between the two electrodes is then amplified and the response is displayed on a pan-recorder or on an oscilloscope.

ERG is elicited both in light-adapted (photopic) and dark adapted (scotopic) states. The usual ERG response is biphasic.

A-wave: an initial negative deflection or late receptor potential, which arises from the photoreceptors.

B-wave: second positive deflection which is generated by muller's cells, but represents processes occurring in the bipolar cells region.

The ERG therefore is a function of the first two neurons of the retina and is not useful in the diagnosis of disorders affecting the ganglion cells or the optic nerve. The ERG produced by stimulating an amblyopic eye with flashes of light is normal even when only the fovea is illuminated.

Recently, however, ERG responses have been generated with patterns of checks similar to those used to elicit the pattern VEP. The pattern ERG is definitely abnormal in many amblyopes. This finding represents the most convincing evidence to date that there may be an abnormality at the retinal level in amblyopia. The mechanism by which the pattern ERG is produced seems to be quite different from that of the flash ERG. Retinal ganglion cells may be responsible for the patterns[3].

Electro-oculogram (EOG):

The electro-oculogram EOG measures the standing action potential which exists between the cornea, which is electrically positive, and the back of the eye, which is electrically negative.

In recording the EOG, electrodes are attached to the skin near the medial and lateral canthi. The patient is then asked to look rhythmically from side to side making excursions of constant amplitude. Each time the eye is moved the cornea makes the electrode nearest to it positive with respect to the other.

The potential difference produced between the two electrodes is amplified and recorded. The test is performed in both light-adapted and dark-adapted states.

Because there is much variation in the EOG amplitude in normal subjects, the result is calculated by dividing the level of the maximal height of the potential in the light (light peak) by the minimal height of the potential in the dark (dark trough). This ratio is then multiplied by 100 and expressed as a percentage. A normal value is over 185%. Because the test needs cooperation of the patient, the test can not be performed on the very young.

The electro-oculogram (EOG) is a test of retinal function, in which changes in the standing potential (SP) of the eye are made manifest. The SP of the mammalian eye is generated primarily by

a potential difference between the apical and basal membranes of the retinal pigment epithelium (RPE) in darkness the potential falls to a trough value (the dark trough D.T.).

In response to light there is a dose dependent increase in the potential difference, developing over several minutes to a peak value (the light peak L.P.) then slowly declining to basal levels. Dopamine has been implicated in the generation of the SP in animal studies and shown to affect the DT in normal human subjects. There is evidence that systemic dopamine can improve visual function in the elderly and in amblyopic adults and children. Dopamine has been proposed as affecting the changes in the depolarization of the PRE which leads to the LP.

Findings demonstrate that the EOG is abnormal in some amblyopic subjects. Results demonstrated that the normalized mean EOG amplitudes obtained from a group of amblyopic eyes were significantly lower than the normalized mean amplitude from the fellow eyes.

The reduction in EOG amplitude was constant in all conditions of light and dark adaptation tested. This is illustrated by the fact that the LP/DT ratios for all subjects were normal. The LP and DT were equally affected, therefore the LP/DT ratio remained normal. Results support a retinal abnormality in amblyopia and suggest that dopaminergic mechanisms may be involved[29,83].

Chapter Two

Patients and Methods

The aim of this study is to estimate the magnitude of amblyopia exanopsia among visually defected patients attending the refraction department in Khartoum Eye Teaching hospital in a period from the 1st of January 1997 to 30th of April 1997.

A total number of 3000 patients with visual defects were sorted out by me during the study period. refraction was done for every patient. Refraction under dilatation and a post mydriatic testing were done whenever needed. Patients with corrected refractive errors were sorted out. History taking and a further detailed examination were done to those patients in whom corrected visual acuity did not improve beyond 6/9 or less.

History including age, sex, occupation and residence were registered. Complaints, past medical and ophthalmic history were recorded. Family history of eye disease including strabismus and refractive errors, birth history and bad habit were also recorded. Finally history of previous treatment including glasses, occlusion, orthoptic exercises and surgeries were registered (see Performa attached).

All amblyopic patients underwent clinical eye examinations starting with visual acuity using Snellen's chart placed at six meters from the patient, each eye was separately tested with and without correction. Contact lens trial was done to all amblyopic patients.

Lids, Lacrimal apparatus, conjunctiva, cornea, anterior chamber, pupil, lens were examined using focal light (torch) and biomicroscopy. Intraocular pressure was measured using Shioetz's tonometer for every patient. Direct ophthalmoscopy was used for posterior segment examination for all patients. Indirect ophthalmoscopy was done whenever needed. Full orthoptic

examination was done by an orthoptist including cover test, ocular motility, Moddox wing, Moddox rod and testing binocular function using synoptophore. A Proforma was filled to reveal all the information available.

Diagnosis of Amblyopia:

In the current study the diagnosis depended mainly on the history, clinical picture, refractive status and orthoptic examination which were confirmed by my supervisor.

Using the criterion of a visual acuity of 6/9 or less with no obvious structural disease to define amblyopia ex-anopsia.

Amblyopia was classified as organic if visual acuity drop is associated with structural ocular pathology of various causes including retinal and optic nerve disease.

Strabismic amblyopia was defined if any form of tropia was found at the time of diagnosis.

Anisometropia was defined if either the spherical or cylindrical difference in refraction between the two eyes was more than one dioptre.

High myopia was defined if myopia equal to or more than eight dioptres was found.

Astigmatism was defined if the difference between the two major axes is more than one dioptre.

Stimulus deprivation is defined if there is opacity in the cornea or the lens or when there is congenital ptosis.

Chapter Three

RESULTS

A total number of three thousand patients (3000) who attended the refraction department because of defective vision, with visual acuity less than 6/9 in one or both eyes were seen in a period from January 1997 – April 1997.

Two thousands and eight hundred (93.4%) patients out of the total number were refractive errors correctable either with glasses or contact lenses, and all had maintained binocular functions.

Fifty (1.7%) patients had defective vision due to diseases of the optic nerve and retina or trauma (organic amblyopia).

One hundred and fifty (5%) patients out of the total number were diagnosed as functional amblyopia (amblyopia ex-anopsia).

Among the causes of organic amblyopia were:

1- Retinal detachment 8 cases (16%).

2- Optic neuropathy 16 cases (32%).

3- Healed penetrating eye injuries 2 cases (4%).

4- Toxoplasmosis 6 cases (12%).

5- Marfan's syndrome 1 case (2%).

6- Macular hole 2 cases (4%).

7- Retinitis pigmentosa 6 cases (12%).

8- Optic atrophy 7 cases (14%).

9- Macular degeneration 2 cases (4%).

(Table 1).

This study was done in one hundred and fifty patients, who were diagnosed as functional amblyopia. Seventy seven out of this number (51.3%) were males and 73 (48.7%) were females *(Table 2)*.

Fourty four out of the functionally amblyopes were fifteen years old or less (29.4%), 18 (41%) were males and 26 (59%) were females.

Eighty two (54.6%) were in the age group from 16 – 30 years, 44 (53.7%) were males and 38 (46.3%) females.

Twenty four (16%) patients were thirty one year or more. 15 (62.5%) were males and 9 (37.5%) were females *(Table 3).*

Out of the functionally amblyopic patients, 40 (27%) patients were strabismic, 24 (60%) females and 16 (40%) males *(Table 4).*

Thirty six (90%) estropes, 24 (66.7%) females, 12 (33.3%) males.

Four exotropes (10%), 4 (100%) males, none females *(Table 5).*

Eight (5.3%) patients had stimulus deprivation, 4 (50%) females, 4 (50%) males, 6 (75%) patients had congenital cataract, 2 (33.3%) males and 4 (66.7%) females. Two (25%) corneal opacity, both were females *(Table 6).*

Seventy (46.3%) patients had anisometropia. 42 (60%) males, 28 (40%) females.

Anisohypermetropia 38 (54.2%) patients: 12 (31.6%) females, 26 (68.4%) males.

Anisomyopia 32 (45.8%): 16 (50%) females, 16 (50%) males *(Table 7).*

Thirty two (21.4%) patients were highly ametropic. 15 (46.9%) males, 17 (53.1%) females.

Myopic ten (31.25%), 4 (40%) females and 6 (60%) males.

Hypermetropic Four (12.5%): One (25%) male, 3 (75%) females.

Astigmatic eighteen (56.25%): 10 (55.6%) females, 8 (44.4%) males *(Table 8).*

One hundred and twenty eight patients (85.3%) out of the total number had unilateral amblyopia, while the remaining 22 (14.7%) patients had bilateral amblyopia *(Table 9).*

Right-sided amblyopes were 54 (42.2%) patients and left sided amblyopes were 74 (57.8%) patients were seen among the unilateral amblyopes *(Table 10).*

Age groups from 5 – 15 years.

Total number was fourty four patients

Strabismic patients were 28 (63.6%), stimulus deprivation were 8 (18.2%), anisometropia were 4 (9.1%) and highly ametropic 4 (9.1%).

Age group from 16 – 30 years

Strabismic patients were 12 (14.6%), stimulus deprivation 0, anisometropia were 54 (65.9%) and highly ametropic 16 (19.5%).

Age group from 31 years and above.

Total number was twenty four:

Strabismic patients 0, stimulus deprivation 0, anisometropia were 12 (50%) and highly ametropic 12 (50%). (*Table 11)*

Chapter Four

Discussion

The lack of randomization and statistical control of studies is one of the weakest aspects of the amblyopia literature.

The present study has the advantage of addressing this issue for the first time, but it has the limitation of all hospital-based studies in that the epidemiological results are not comparable with those of population based investigations. This hospital-based study was done at Khartoum Eye Teaching Hospital in the period from October 1996 to December 1997. Data was collected in a period of four months from the 1st of January 1997 to the 30th of April 1997.

Out of the total number of 3000 patients attending the refraction department because of defective vision, 2800 patients were found to have refractive errors, correctable by any means of correction, 50 patients were organically amblyopic due to diseases of the optic nerve retina and trauma. Out of the total number, 150 patients were functionally amblyopic making a percentage of 5% of the population studied.

Although this percentage cannot be generalized because it is a hospital-based study, it only reflects the magnitude of amblyopia among patients attending the hospital. Males 77 patients (51.3%)

were found to be more affected than females 73 patients (48.7%). All were Sudanese except for one patient coming from Niger. The majority of amblyopic patients 82 patients (54.6%) were found in the age group from 16 – 30 years followed by the age group 5-15 years 44 patients (29.4%) the youngest being 5 years old.

This is considered a late presentation. Younger age group were not included in our study because patients of this group are difficult to examine as most of them need examination under general anaesthesia, also assessing their visual acuity is another problem. Beside that these young patients are not brought up by their parents, seeking medical advice unless there's an apparent cause such as strabismus, as these patients present earlier than the other types, or when the defective vision is accidentally discovered at school age. This shows the importance of survey studies for amblyopia to be detected early, as parents do not know that an eye with squint or visually defected early, may become permanently lazy because of delayed treatment.

Unilateral amblyopia was common in our patients 128 representing (85.4%) out of the total number; while bilateral amblyopes were 22 patients (14.6%). In a study carried out at king Fahad hospital, Kingdom of Saudi Arabia 1994 (94.3%) of patients had unilateral amblyopia and (5.7%) had bilateral amblyopia[103]. In this study the main cause of bilateral amblyopia remained high refractive errors mainly high myopia.

Right-sided amblyopes were 54 patients (36%) while left-sided amblyopes were (49.4%), our study matches with the study done in Saudi Arabia[103] where right-sided amblyopes were (42.3%) while left-sided amblyopes were (52%). In another study done at University of Leicester, United Kingdom; the authors confirmed a small but significant increase in left-sided compared with right-sided amblyopia[104]. This observation was explained neither by us nor by other authors in literature.

Anisometropia represented the leading cause of amblyopia ex-anopsia in our study affecting 70 patients (46.3%)0 followed by strabismus 40 patients (27%) then comes high errors of refraction

32 patients (21.4%) and lastly stimulus deprivation affecting 8 patients with a percentage of (5.3%).

Anisohypermetropic amblyopes 38 patients (54.2%) were more than anisomyopic amblyopes 32 patients (45.8%). One case with anisohypermetropia and a Duane retraction syndrome type 1. another patient with anisomyopia had a myelinated nerve fiber. It is worth noting that a combination of anisometropia and strabismus were detected in a considerable number of patients although we believe that the primary cause of amblyopia in these patients was anisometropia and the deviation was due to secondary strabismus.

In strabismic patients, esotropia was the commonest 36 patients (90%) and exotropes were 4 patients (10%) in contrast to a study done in Cameroon at Douala General Hospital in which the author found a (37.2%) esotropes and (62.8%) exotropes and concluded the frequency of divergent squint in black Africans which may lead to amblyopia[105]. Coinciding with our study, in Saudi Arabia strabismic[103] patients with esotropia are (92%) while

exotropes were (6.2%). In this study strabismus represented the leading cause of amblyopia ex-anopsia at the age group 5-15 years 28 patients (63.6%) while at age group 16-30 years it represented (14.6%) and none were found at 31 years and above.

Regarding the refractive errors; the majority of patients were astigmatic 18 patients (56.5%) with a higher incidence among females 10 patients (55.6%) compared to males 8 patients (44.4%). The next commonwas high myopia found in 10 patients (31.25%) 6 were males (60%) and 4 females (40%). All these patients had myopia of more than 8 diopters and was complicated with choroido-retinal degenerative changes affecting the retina and macular area. Then comes high hypermetropia (12.5%) 3 females (75%) and 1 males (25%). Stimulus deprivation amblyopia represented the least number of patients 8 (5.3%), 6 had congenital cataract to which surgeries were done they were not followed by neither optical correction nor amblyopia treatment.

We believe that this group of patients presented late seeking medical advice, as it is important in the treatment of these patients

early removal of barriers to well focused retinal image before the age of 6 months. Greater number of stimulus deprivation is expected if survey studies were done.

CONCLUSIONS

From the analysis of the results obtained from this study, the following conclusions can be made:

1- The percentage of amblyopia ex-anopsia among the visually defected patients attending Khartoum Eye Teaching hospital was (5%) which is within the range of world statistics.

2- The percentage of amblyopia ex-anopsia was higher in males than in females and the commonest age group detected is from 16-30 years in Sudan.

3- The percentage of organic amblyopes was (1.7%) out of the total number of patients with defective vision.

4- The vast majority of amblyopic patients were found to belong to the anisometropic group (46.3%) followed by strabismic patients (27%) then comes highly ametropic amblyopes (21.4%) and lastly the stimulus deprivation group (5.3%).

5- Unilateral amblyopia was found in (85.3%) of patients, while bilateral amblyopia in (14.7%). The main cause of bilateral amblyopia was high myopia.

6- Left-sided amblyopia represents (57.8%) of unilateral amblyopic patients while right-sided amblyopia was (42.2%).

7- Greater number of patients with stimulus deprivation amblyopia was expected if a survey study was done rather than hospital-based study.

8- The main refractive error leading to amblyopia was astigmatism (56.25%); followed by high myopia (31.25%) then comes high hypermetropia (12.5%).

RECOMMENDATIONS

Based on the above conclusions; the following recommendations can be made:

1- Health education programmes must be developed to improve community awareness of visual defects,

strabismus, their relation to amblyopia and early treatment.

2- Screening for defective vision should be carried out at younger age groups especially at pre-school age children for early detection of amblyopia and amblyopiogenic factors.

3- General practitioners and pediatricians should be trained to recognize ocular abnormalities in their patients, especially strabismus and refractive errors and to refer suspicious cases promptly.

4- Introduction of advanced new techniques for measuring visual acuity in young children below 5 years of age and toddlers.

5- The need for a well-equipped department in our hospital for the investigation, treatment & follow up of amblyopic patients.

TREATMENT OF AMBLYOPIA

The treatment of amblyopia is a very important element in the management of such patients. When the amblyopia is not successfully treated in childhood, the patient will live the entire life with the risk of suffering serious visual disability. Amblyopia is a preventable cause of visual impairment.

Therefore most cases of amblyopia detected during the first decade of life, can be electively treated. The earlier the therapeutic measures are initiated, the greater the chance of success. The type of treatment which is most suitable for a particular patient depends on the age of the patient, the type of amblyopia, and the degree of cooperation attainable.

The treatment of amblyopia must begin, whenever possible, with the removal or modification of the amblyopiogenic factors. This means glasses should be prescribed for refractive errors and anisometropia. Opacities in the media such as cataract or corneal opacity must be eliminated, and appropriate optical correction

provide. The main factor which affects the outcome in children treated for amblyopia is the initial visual acuity. The outcome is best for pure anisometropic amblyopia, intermediate for pure strabismic and least good for mixed strabismic and anisometropic amblyopia.

Poor compliance is also associated with poor outcome. Non compliance is known to reduce the improvement a child could achieve from treatment[83]. Children do not like having their eyes occluded, and thus, in previous studies the outcome of amblyopia treatment, 30% - 59% of children have been excluded from analysis because of non-compliance.

Parents may be reluctant to bring their child into the clinic if they are failing to apply prescribed treatment at home. Centers that arrange more visits in the first year of treatment had higher ratios of compliance[84-86].

This perhaps shows that these centers reinforce the importance of treatment compliance by inviting the patient into the clinic more frequently. There's well established relationship

between social deprivation and access to health care and so it is supposed that social deprivation might be associated with non-compliance.

Components of treatment of amblyopia consist of:

1- Occlusion (patching):

Visual acuity in the amblyopic eyes can be improved by patching therapy of the good eye in most patients older than 7 years, but the acuity improvement is higher in younger patients. At least 67% of all amblyopes followed for one year lost some of the acuity gained after cessation of therapy, regardless of the eye when treated.

As reduction of the acuity gain is likely to occur within the first year after cessation of therapy it is recommended that amblyopic patients of all ages be followed at regular intervals[87].

Occlusion may be complicated by patch intolerance resulting in poor compliance. So the use of occlusive contact lenses in the treatment for those who cannot tolerate eye patching or who failed conventional treatment is better. An opaque hydrogel contact lens

is used, however, because of the potential for complications, their use is limited[88].

Monitoring the anterior segment complications from contact lens use should be done, and also identifying the patients in whom amblyopia recurs. Other possible problems include the risk of over treatment of the better eye, resulting in occlusion amblyopia.

A) Direct occlusion:

is occlusion of the sound eye so as to force the child on using the amblyopic eye. Methods of occlusion includes:

(1) Total occlusion:

i.e. occlusion which obscures both light and form. It is usually necessary when there is marked amblyopia. Types of total occluders:

- Elastoplast total occluder applied to the skin around the eye-lid to obscure vision in that eye.
- Zinc oxide adhesive plaster oclcuder attached to spectacle frame

(2) Partial occlusion:

i.e. occlusion which obscures form only, used in cases in which binocular single vision is present e.g. cases of intermittent squint; also when the degree of amblyopia is slight e.g. 6/12 or better.

Type of partial occluders:

- Brown or white paper
- Transparent sellotape
- Soap and colourless nail varnish
- Atropine 1% eye drops used in the fixing eye as a mean of occlusion. It is no value unless it sufficiently reduces visual acuity of the fixing eye so that the squinting eye is used for fixation. Development of occlusion amblyopia in the sound eye following atropine therapy for stabismic amblyopia has been mentioned[89].

The first sign of developing occlusion amblyopia is the decrease of fixation ability in the sound eye in a binocular fixation test prior to reduction of visual acuity. This occlusion amblyopia is not the result of deprivation but is due to the reversal of the eye

used for fixation. Strabismic amblyopia may have the tendency towards an alteration between fixation abilities of the two eyes and such as binocular sensory anomaly may cause strabismic amblyopia itself[90].

B) Inverse occlusion:

Is occlusion of the non-fixing eye so as to prevent further stimulation of an eccentric point and to give the amblyopic eye a chance to regain its central fixation. It may be used alone or in combination with pleoptic treatment.

An important question arises, when is it safe to stop patching? In general, patching can be safely discontinued after the child's third birthday, although follow up after primary occlusion is important to ensure stable results in all patients. Preverbal children are more likely to require maintenance patching[91]. Because of the increased chance of developing occlusion amblyopia in young children short follow up periods are recommended. Also the necessity of monitoring the occlusion by VEP recording to prevent the detrimental effects of visual

deprivation on the development of the system of vision in a child[92]. In an effort to prevent the development of occlusion amblyopia, an age dependent regimen of occlusion has been adopted by Von Noorden.

In the first year of life, the sound eye is patched three days and the amblyopic eye one day (weekly), in the second and third year the sound eye is patched four days and the amblyopic eye one day. In the fourth and fifth year the sound eye is patched five days and the amblyopic one day. At the age of six years and above the sound eye is patched six days and the amblyopic one day and the cycle is repeated[72].

Age (years)	Period (weekly)
0 -1	3 :1 days
2 -3	4 :1 days
4 – 5	5 :1 days
6 – above	6 :1 days

Occlusion therapy has also succeeded in improving the visual functions of some children with structural defects of the macula or the optic nerve (organic amblyopia) [93]. Full time occlusion therapy was tried in pediatric patients with monocular structural abnormalities and amblyopia (partial media opacity, macular lesion or optic nerve abnormality). In a study done by Bradford; Kutschke and Scott; they noticed that amblyopia recurred in 31% of patients and was successfully treated with resumption of full-time occlusion. They recommended a trail of full-time occlusion for patients with all three types of unilateral structural abnormalities. The patients with partial media opacities have a high success rate. Despite lower success rates for the other two groups, good results are possible since no better treatment option exists[94].

(2) Penalisation:

The term penalization indicates a form of treatment which forces the patient to use one eye for distance and the other for near

by means of lenses and/or drugs i.e. optical or pharmacological penalization.

a) Near penalization:

By instilling 1% atropine every day into the fixing eye while a fresnel lens of strength varying between +1.50 Ds to +4.00 Ds is added to the spectacle lens before the amblyopic eye. The patient, while still able to use the normally fixing eye for distance; is thus prevented from using it for near fixation.

Near penalisation may also be achieved by prescribing 1% atropine for the fixing eye and 0.06% phospholine iodide each evening for the amblyopic eye.

b) Distance penalisation:

The atropinised fixing eye is handicapped for distance by a fresnel +3.00 Ds which allows clear near vision; while the amblyopic eye has no atropine but merely the normal refractive correction. The amblyopic eye is thus forced into use for distant vision and may also be used for near.

c) Total pensalisation:

The fixing eye is limited by instillation of 1.0% atropine daily coupled with a fresnel –4.00 Ds or -5.00 Ds lens thus making clear vision for both near and distance impossible.

For the amblyopic eye a full refractive correction is prescribed in some instances; placed in a condition of miotic-induced myopia with the use of phospholine iodide 0.06% each evening.

The advantages of penalisation over conventional occlusion include:

i) That at no time is the deprivation of light stimulus to either eye.

ii) There is no chance of the patient peeping round a patch so that the child's active co-operation is not required.

iii) There is no aggravation of latent nystagmus.

Disadvantages includes:

i) Long-term use of drugs

ii) The long time-lag between discontinuing the use of drugs and the end of their influence, so that treatment cannot be abruptly discontinued.

iii) The twice-daily instillations which children often do not enjoy.

Repka and Ray were the first to do a long scale study on the use of atropine occlusion as a first treatment rather than as last resort. They also concluded that penalisation should be considered more often for the primary treatment of amblyopia.

They suggested the use of the pharmacological penalisation for higher degree of amblyopia (< 20/60 6/18) whereas penalisation is best reserved for patients with lesser amblyopia (20/25 6/9 – 20/60 6/18). The other study was by North and Kelly where they concluded at the end of their study, that permanent reversal of amblyopia is rare, and unwanted side effects are few and of a minor nature.

Pupil size, light reflex and accommodation of the atropinised eye were not affected after cessation of treatment, also the angle of strabismus was unaffected[95].

(3) Pleoptics:

The techniques of pleoptics were developed in Switzerland by Bangester and Germany by Cuppers and was used more in the 1950s and 1960s particularly in Europe. Pleoptics involve projecting bright light on the perifoveal retina to dazzle the eccestrically fixating area and then stimulating the fovea with either formed after-images or exercises designed to restore the ability to fixate.

Nowadays it has declined greatly in value and popularity and has been discontinued in many countries for various reasons, mainly because earlier and better screening of vision has improved the results of occlusion therapy and because its cost/benefit ratio has been considered unfavourable.

In a study done by Pasmanik and Nizovtseva where 52 children were treated by acupuncture and traditional pleoptics,

this complex of treatment was found more effective as against traditional pleoptics alone, in the treatment of high amblyopia. The best result were attained in children previously treated by pleoptic methods with special equipment. The first course of such treatment proved to be the most effective in the treatment of high amblyopia, starting from the second course the condition grew resistance to such treatment, this resistance gradually augmenting[54].

In a study done in Finland by Koskela and Mikkola (1991) concerning the permanent result of pleoptic treatment, they found that the poorest results were found in the combined strabismic and anisometropic amblyopia group, and that the final visual acuity correlated positively with the initial vision acuity and negatively with age at the time of treatment and that binocular single vision improved the prognosis[96].

(4) Strip therapy Cambridge vision stimulator (CAM):

Recent experiments have greatly increased our knowledge on the physiology of vision and the aetiology of amblyopia. It has

been demonstrated that visual cells in the brain respond best to gratings of a particular size and orientation and a form of treatment has been devised at Cambridge which attempts to respond to this new knowledge by stimulating the amblyopic eye with gratings in all orientations.

This is achieved by an instrument, the Cambridge vision stimulator (or the cam) on which concentrated close work is carried out on a transparent plate, behind which is a disc of square-wave gratings of selected size which rotates at one revolution per minute, thus constantly altering the orientation of the gratings. Total occlusion is worn over the normally fixing eye for seven minutes and the amblyopic eye is used with intense concentration in games and exercises devised for different age group[37].

(5) Prisms:

Sporadic reports of the use of prisms in the treatment of amblyopia, particularly of amblyopia with eccentric fixation, have appeared in the literature of the past 14 years.

Various applications of the prism over the amblyopic eye have been recommended; including base-out and base-in. Another report calls for the use of such amount of prism in front of the dominant eye as to place the amblyopic eye in the primary position[37].

(6) Home exercises:

This method has found a place in amblyopia therapy. A series of graded targets for use in home exercises has been described by Weiss.

Home exercises are particularly valuable in the amblyopia who has reached the level of 20/70 (6/24) or better and whose fixation is basically central although unsteady. Their use at this stage of amblyopia therapy appears to accelerate progress in the improvement of the acuity towards the desired level.

(7) Other means of treatment: (Levodopa/carbidopa)

neurotransmitter dopamine (DA) is involved in several visual functions. It was noticed that visual deprivation decreases retinal DA concentration in chickens and monkeys. In a study

done by Leguire, Rogers and Bremer in Ohio to evaluate the efficiency and tolerance of levodopa/carbidopa treatment for amblyopia, they found that one hour after drug ingestion, Snellen's acuity, contrast sensitivity and pattern VEP temporarily improved in both dominant and amblyopoic eyes, whereas the visual function remained stable in normal eyes. The improvements in visual function started to decrease 5 hours after drug ingestion[97]. An average dose levels of 0.95/0.24 mg/kg and 1.49/0.49 mg/kg of levodopa/carbidopa were found to be well tolerated and efficacious at temporarily improving visual acuity in amblyopic eyes of children[98]. Also improved visual function in amblyopic children was attained; when levodopa/carbidopa at an average of 0.48/0.12 mg/kg combined with part-time occlusion[99]. Also good results were obtained in older children (means age 8.87 years). Studies also have shown that both a single dose of levodopa and a one-week administration of levodopa improve visual functions in adult amblyopia patients, however increasing the dosage and the duration of levodopa did not enhance the effect

in adults[100]. In adult strabismic amblyopic patients a short-term effect of levodopas on contrast sensitivity and fixation point scotoma was detected[101].

Citicoline

Citicoline has been used to improve consciousness levels in cerebral trauma and as a complement for levodopa in parkinson's disease. It has also been shown that severe glaucomatous visual field deficits improve for at least 4 months with the use of citicoline. Citicoline improves visual acuity at least temporarily, in amblyopic patients beyond the plastic period of the visual system. Results suggest that trials of citicoline as a medical treatment of amblyopia are promising[102].

Objectives

The purpose of this study is:

1) To evaluate the magnitude of amblyopia exanopsia among the patients seen in K.E.T.H. in a period from the 1st of January 1997 to the 30th of April 1997.

2) To detect the different causes of amblyopia ex-anopsia in K.T.E.H.

3) Helping the patients by drawing their attention to the right time for treatment of amblyopia in treatable cases to minimize severe visual impairment.

ent0**References**

(1) Simons K. Pre-school vision screening: national methodology and outcome. Surv Ophthalmol 1996; 4(1): 3-30.

(2) Sala NA. Amblyopia and strabismus. Pa Med 1996; 99 (1): 63-6.

(3) Duane TD Jaeger EA. Amplyopia. Clinical Ophthalmology, 2nd. Philadelphia: J B Lippinocott; 1988. 1-15.

(4) Fraser H. Amblyopia or Lazy eye. Aust Fam Physiol 1995; 24(6): 1021-23.

(5) Wrck B, Wingard M, Cotler S, Scheiman M. Aanisometropic amblyopia is the patient ever too old to treat?. Optum Vis Sci 1992; 69 (11): 866-78.

(6) Mayer DL, Gross RD. Modified Allen pictures to assess amblyopia in young children. Ophthalmol 1990; 97 (6): 827-32.

(7) Camposs E. Amblyopia. Surv Ophthalmol 1995; 40 (1): 23-39.

(8) Gillic JC, Lindsay J. Orthoptics: a discussion of binocular anomalies. London: The Hetton Press Ltd; 1969. 23-5.

(9) Rubin SE, Nelson LB. Amblyopia diagnosis and management. Paeditrics 1993; 40: 727-35.

(10) Sjostrand J, Abrahamsson M. Can we identify risk groups for the development of amblyopia and strabismus? Klin Monatsbl Augenheikd 1996; 08(1): 23-6.

(11) Gusek GC, Martus P, Schonherr HM. Sensitivity of refraction measurement with the infra red refractometer VRB 200. Klin Munatsbi Augenheikd 1995; 207(4): 232-38.

(12) Magramm I. Amblyopia aetiology, detection and treatment. Pediatr Rev 1992; 13 (1): 7-14.

(13) Summers GG, Romig L, Lavore SD. Unexpected good results after therapy for anisometropic amblyopia associated with unilateral peripapillary myelinated

nerve fibres. J Pediatr Ophthalmol Strabismus 1991; 134-38.

(14) Kassir M. An Exhausive study of the frequency of vision disorders in children 5-18 years or a Lebanese school. Sante 1996; 6(5): 323-26.

(15) Payman GA, Saunders DR, Goldberg MF. Strabismus. Principles and practice of ophthalmology, 1st. ed. Vol 3. India: Jaypee Brothers India 1987. 1778-887.

(16) Fells P. Amblyopia a historical perspective. Eye 1990; 4(6): 775-86.

(17) Van Noordon GK, Grawford ML. The lateral geniculate nucleus in human strabismic amblyopia. Invest Ophthalmol Vis Sci 1992; 33(9): 2729-732.

(18) Von Noordon GK. Amploypia. Binocular vision and ocular motility, 4th ed. St Louis: CV Mosby; 1996. p. 73-4.

(19) Hess RF. Amblyopia a tale

.76-69 :(2) 44 ;1996 hthalmolp

(20) Makee SP, Harred RA. Fusional suppression in normal and stereo anomalous observers. Vision Res 1993; 33(12): 1645-648.

(21) Duffy FH, Burchfiel JL, Snodgrass SR. The pharmacology of amblyopia. Ophthalmology 1978; 85(5): 10-5.

(22) Hess RF. The site and nature of suppression in squint amblyopia. Vision Res 1991; 31(1): 111-17.

(23) Alfaro DV, chandling NA, Walonker AF, Runyian T, Saito Y, et al. Penetrating eye injuries in young children. Retina 1994; 14(3): 201-5.

(24) Horton JC, Stryker MP. Amblyopia induced by anismometropia without shrinkage of ocular dominance columns in human striate cortex. Proc Natl Acad Sci 1993; 90(12): 5494-498.

(25) Sengpiel F, Blackmore C. The neural basis of suppression and amblyopia in strabismus. Eye 1996; 10(Ptz): 250-58.

(26) Perkins ES, Hill DW. Amblyopia. Scientific foundations of ophthalmology, 1st ed. London: William Hienman Medical Book Ltd; 1977. 104-107.

(27) Keech RV, Kutschke PJ. Upper age limit for the development of amblyopia. J Pediatr Ophthalmol Strabismus 1995; 32(2): 89-93.

(28) Kanski JJ. Stabismus. Clinical Ophthalmology, 3rd ed. Oxford: Buttermorth Heineman; 1989. 430-40.

(29) Baranowska GT. Hisstory of strabismology in the countries of western Europe. Klin Oczna 1996; 98(3): 249-52.

(30) Costanbader FD, Allen JH. Amblyopia. Clinical course and management of esotropia, 1st ed. St Louis: CV Mosby; 45-50.

(31) Tayler MO. How early is surgery in the management of strabismus? Arch Ophthalmol 1963; 70: 752-56.

(32) O'Keefe M, Abdulla N, Bowell R, Lanigen B. Binocular function and amblyopia after early surgery in infantile esotropia. Acta Ophthalmol Scand 1996; 70(5): 461-62.

(33) Dahlke C, Dodt E. Amblyopic eyes produce an abnormal electro retinogram in pattern presentation with the on-off technique. Ophthalmol 1993; 91(2): 176-80.

(34) Cibis T, Stasslser N. Amblyopia. Decision making in pediatric ophthalmology, 1st ed. St Louis: Bc-Decker; 1993. p. 182-188.

(35) Smith EL, Harworth RS, Sidoor J, Wingard J, Crawford MC, et al. Prior binocular dissociation reduces monocular from deprivation amblyopia in monkeys. Invest Ophthalmol Vis Sci 1992; 33(5): 1804-810.

(36) Cashell GT, Duran IM. Treatment of amplyopia. Handbook of Orthoptic Principles. London: E & S Livingstone Ltd; 1967. p. 106-110.

(37) Motteno AC, Hodgkinson IJ, Hoare NJ, Sanderson GF, Peart DA. Reliability of the otago photoscreener. A study

of a thousand cases. Aut NZ J Ophthalmol 1993; 21(4): 257-63.

(38) Yand S, Lin J, Lui X. Refrective error and amblyopia in children. Ye Ko Hsuch Pao 1992; 8(4): 173-78.

(39) Sinsky RM, Amin PA, Linguire R. Catarct extraction and intraocular lens implantation in an infant with a monocular congenital cataract. J Catarct Refract Surg 1994; 20(6): 647-51.

(40) Kornacki B, Goryzyewska M, Maciouch H, Sadowska E. Must an eye after unilateral congenital cataract surgery be amblyopic. Klin Oczna 1993; 95(7): 281-84.

(41) Moore BD. Optometric management of congenital cataract. J Am Optom Assoc 1994; 65(10): 719-24.

(42) Anwar M, Bleik JH, Von Noorden GK, El Maghraby AA, Attia F. Posterior chamber lens implantation for primary repair of corneal lacerations and traumatic cataract in children. J Pediatr Ophthalmol Strabisms 1994; 31(3): 157-61.

(43) Manners RM, Tyers AG, Morris RJ. The use of prolene as a temporary suspensory material for brow suspensionin young children. Eye 1994; 8(3): 346-48.

(44) Maculloch DC, Wright KW. Unilateral congenital ptosis compensatory head posturing and amblyopia. Ophthalmol Plast Recustr Surg 1993; 9(3): 196-200.

(45) Stark N, Zubeov AA, Kast E, Gutermuth D. Amblyopia, refractive errors and strabismus in congenital ptosis. Ophthamolgy 1996; 93(4): 345-50.

(46) Bredemyer HG, Bullock K. Orthoptics theory and practice. St. Louis The S.C. Mosby Company; 1968. 45-50.

(47) Latvala ML, Palaheimo M, Karma A. Screening of amblyopic children and long term follow up. Acta Ophthalmol Scand 1996; 74(5): 488-92.

(48) Rizzo JF, Lessell S. Tobacco amblyopia. Am J Ophthalmol 1993; 116(1): 84-7.

(49) Ordunez-Garcia PO, Nicto FJ, Espriosa-Brito AD, Cabeller B. Cuban epidemic neuropathy 1991-1994. Am J Pub Hlth 1996; 86(5): 738-43.

(50) Oku H, Fukushimer K, Miyato M, Wakakura M, Ishika S. Cyanide with vit B_{12} deficiency as the cause of experimental tobacco amblyopia. Nippon Gauka Gakkai Zasshi 1991; 95(2): 158-64.

(51) Golnik KC, Schaible ER. Folate responsive optic neuropathy. Neuro Ophthalmol 1994; 14(3): 163-69.

(52) Young L, Weis JR, Summer RG, Egbert JE. The association of strabismus, amblyopia and refractive errors in spasmus nutans. Ophthalmology 1997; 104(1): 112-17.

(53) Pasmanik EO, Nizovtseva TR. The combined treatment of amblyopia by the methods of acupuncture reflexotherapy and traditional pleoptics. Vestn Oftalmol 1993; 109(4): 6-8.

(54) Siretennu R, Fronuis M, Katz B. A persective on psychophysical testing in children. Eye 1990; 4(6): 794-801.

(55) Giaschi DE, Regan D, Kraft SP, Kothe AC. Crowding and constrast in amblyopic. Optum Vis Sci 1993; 70(3): 192-79.

(56) Bremer MH. Visual acuity in the primary school child aged from 7 to 12 years: a review of amblyopia treatment in this age group at princess Margret hospital. Aut J Ophthalmol 1983; 12: 395-99.

(57) Friendly DS, Jaafar MS, Morillo DL. A comparative study of grating and recognition visual acuity in children with anisometropic amblyopia without strabismus. Am J Ophthalmol 1990; 110(3): 293-99.

(58) Nordman JP, Freeman RD, Casanova C. Contrast sensitivity in amblyopia: masking effects of noise. Invest Ophthalmol Vis Sci 1992; 33(10): 2975-986.

(59) Muller KT, Sankeralli MJ, Hess RF. Colour and luminance vision in human amblyopia shifts in isoluminance, contrast sensitivity losses and positional deficits. Vision Res 1996; 36(5): 645-53.

(60) Cox JF, Suh S, Leguire LE. Vernier acuity in amblyopic and non-amblyopic children. J Pediatr Ophthalmol Strabismus 1996; 33: 39-46.

(61) Gobin CV, Gobin MH. Photographic screening for amblyopia, strabismus and refractive errors. Bull Soc Belge Ophthalmol 1992; 243: 37-44.

(62) Deutsch J, Smellie TS, Tovey J. Photorefraction two methods and their clinical application. Anchiov Media Med 1990; 13(4): 124-28.

(63) Gobin CV. Photoscreening. Bull Soc Belge Ophthalmol 1994; 253: 91-4.

(64) Freedman HL, Preston KL. Palaroid photoscreening for amblyogenic factors, an improved methodology Ophthalmol 1992; 99(12): 1785-795.

(65) Hope C, Roulston J, Hoey C, Wang A. Community photoscreening at six to nine month old infant for amblyogenic risk factors. Aut N Z J Ophthalmol 1994; 22(3): 193-202.

(66) Molteus AC, Hodgkinson IJ, Havitt GJ, Sandersen GF. The development of fixing and focusing behaviour in normal human infants as observed with the Otago photoscreener. Aut N Z J Ophthalmol 1993; 20(3): 197-209.

(67) Miller JM, Hall HL, Greivenkamp JE, Guyton DL. Qualification of the Bruckner test for strabismus. Invest Ophthalmol Vis Sci 1995; 36 (5): 897-905.

(68) Cerovski B, Amplyopia and the visual field. Aeta Med Lugosl 1990; 44 (5): 549-54.

(69) Sireteanu R, Fronius M. Human amblyopia, structure of visual field. Exp Brain Res 1990; 79 (3): 603-14.

(70) Khairallah S. Pathological myopia: a review. Saudi J Ophthalmol 1991; 5(3): p. 143-49.

(71) Jaafar MS. The child with a lazy eye. Selected proceedings of the second annual pediatric symposium King Faisal Specialist hospital and research center Riyadh. Riyadh: 1985. p. 5-6.

(72) Mest RA, Ary JP, Wright KW. Automated perimeter for binocular suppression. IEEE Trans Biomed Eng 1990; 37(7): 731-34.

(73) Mantyjarn M, Tuppuraman K. Colour vision and dark adaptation in high myopic with central degeneration. Br J Ophthalmol 1995; 79: 105-108.

(74) Firlty AY. Pupillary response in amblyopia. Ophthalmol 1990; 74(11): 676-80.

(75) Barpur JI, Hess RF, Pinney HD. Pupillary function in human amblyopia. Ophthalmic Physiol Optom 1994; 14(2): 139-49.

(76) Gonzalez DA, Linos A. Anisocornia a suspicious sign of anisotrophy and/or amblyopia. An Esp Pediatr 1991; 34(1): 9-14.

(77) Singh V, Sinta S, Singh GK. A retrospective cohort study for prognostic significance of visual acuity for near over that for distance in anisometropic amblyopia. Indian J Ophthalmol 1992; 40(2): 44-7.

(78) Yan JH, Yang SM. The retinal visual acuity of amblyopia. Chang Hua Yen ICO Isa Chich 1990; 26(2): 73-5.

(79) Kubova Z, Kuba M, Junan J, Blackmore C. Is the motion system relatively spared in amblyopia? Evidence for cortical evoked responses. Vis Res 1996; 36(1): 181-90.

(80) Frosini R, Boschi MC, Campa L. Electrophysiological aspects of amblyopia. J Bull Soc Ophtamol Fr 1990; 90(2): 241-48.

(81) Li S, Cai H, Gue J. The visual evoked potentials of non-amblyopic eyes in children with amblyopia. Chang Hua Yen Ko Chich 1995; 31(6): 422-25.

(82) William C, Papakosta PD. Electro-oculographic abnormalities in amblyopia. Br J Ophthalmol 1995; 79: 218-24.

(83) Kutschke PJ, Scott WE, Keech RV. Anisometropic amblyopia. Ophthalmol 1991; 75: 111-16.

(84) Lang J. Diagnosis and treatment of amblyopia. Ther Unsch 1996; 53(1): 20-4.

(85) Awaya S, Von-Noorden GK. Visual acuity of amblyopic eyes under monocular and binocular conditions further observations. J Pediatr Ophthalmol 1972; 9: p. 35-40.

(86) Rustein RP, Fuhr PS. Efficacy and stability of amblyopic therapy. Optom Vis Sci 1992; 69(10): 747-54.

(87) Eustis HS, Chamberlain D. Treatment of amblyopia results using occlusive contact lens. J Pediatr Ophthalmol Strabismus 1996; 33(6): 319-22.

(88) North RV, Kelly ME. Atropine occlusion in the treatment of strabismic amblyopia and its effect upon the non-amblyopic eye. Ophthalmic Physiol 1991; 11(2): 113-17.

(89) Filchlkova LA, Kruikorshikh ON, Dubovskaia LA, Matvesv SG. The effect of occlusion of the better seeing eye on the funciton of the visual system in children with

unilateral amblyopia. Vestu Ophthalmol 1993; 109(4): 8-11.

(90) Dster JE, Simon JW, Jerkins P. When is it safe to stop patching? Br J Ophthalmol 1990; 74(12): 709-11.

(91) Hillis A, Flyn JT, Hawkins BS. The evolving concepts of amblyopia a challenge to epidemiologist. Am J Epidemiol 1983; 118: 193-205.

(92) Yang LL, Laubert SR. Reappraisal of occlusion therapy for severe structural abnormalities of the optic disc and macula. J Pediatr Ophthalmol Strabismus 1995; 32(1): 37-41.

(93) Bradford GM, Kutschke PJ, Scott WE. Results of amblyopia therapy in eyes with unilateral structural abnormalities. Ophthalmol 1992; 99: 1616-621.

(94) Repka MX, Ray JM. The efficacy of optical and pharmacological penalisation. Ophthalmol 1993; 100 (5): 769-74.

(95) Koskela PV, Nikkola T,LaatiKainen L. Permenant results of pleoptic treatment. Acta Ophthalmol 1991; 69: 39-44.

(96) Lequire LE, Rogers GL, Bremer DL, Walson TO, Hadji C. Levodopa and childhood amblyopia. J Pediatr Ophthalmol Stabismus 1992; 29(5): 290-98.

(97) Lequire LE, Rogers GL, Breuer DL, Walson TD, MacCreger ML. Levodopa/Carbidopa for childhood amblyopia. Invest Ophthalmol Vis Sci 1993; 34(11): 3090-95.

(98) Lequire LE, Walson TD, Rogers GL, Bremer DL, NacGreger ML. Longitudinal study of levodopa/carbidopa for childhood amblyopia. J Pediatr Ophthalmol Strabismus 1993;30(6): 354-60.

(99) Gottlob I, Wizer SS, Reimecke RD. Visual acuities and scotomas after 3 weeks levodopa administration in adult amblyopia. Arch Chin Exp Ophthalmol 1995; 233(7): 407-13.

(100) Gottlob I, Stranger ZE. Effect of levodopa on contrast sensitivity and scotomas in human amblyopia. Invest Ophthalmol Vis Sci 1990; 31(4): 766-80.

(101) Campos EC, Schian C. Benedetti P, Bonazani R, Porciatti V. Effect of citicoline of visual acuity in amblyopia-preliminary results. Graefes Arch Clin Ophthalmol 1995; 233(5): 307-12.

(102) Al-Qahtani J. Amblyopia prevalence and response to therapy. A dissertation submitted in partial fulfillment of the requirement for fellowship in Ophthalmology. King Faisal University Dammam: Saudi Arabia; 1996.

(103) Woodruff G, Hiscox F, Thompson WR, Smith LK. The presentation of children with amblyopia. Eye 1994; 8(6): 623-26.

(104) Ebana MC, Bello H, AlEpesse M. Strabismus in Cameroon. J Fr Ophthalmol 1996; 19(11): 705-9.