

insight

Vol. XXVIII No. 1

FEBRUARY 2010

Scientific Journal of
MEDICAL & VISION RESEARCH FOUNDATIONS
18, COLLEGE ROAD, CHENNAI - 600 006, INDIA

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Editorial

Dear readers

We wish you a happy new year. May this year fill you with new learning and knowledge. This issue carries a perspective article on Epiphora and management of the same. An article from the Elite School of Optometry looks at visual impairment in the multiple disabled children. The article on Biologics in Uveitis covers comprehensively that pharmacological class of agents. A muscle puzzle to test your thinking skills follows. There is a continuing segment on Biostatistics. An interesting case report from the Department of Anaesthesia looks at a common but serious post-anesthetic problem. Femtosecond laser is introduced and elaborated upon in the technology update.

S. Meenakshi
Editor

AN APPEAL

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Perspective

Diagnosis of epiphora and management of acquired nasolacrimal duct obstruction

M. Varde and B. Mukherjee

PHYSIOLOGY OF THE LACRIMAL DRAINAGE SYSTEM

Etiology of epiphora

When a patient complains of tearing, the first step is to determine whether it is caused by an increase in tear production (lacrimation) or a decrease in tear drainage (epiphora). Ocular surface irritation due to trichiatric lashes, foreign bodies, eyelid malpositions, blepharitis or meibomitis, and tear film instability may cause an abnormal increase in tear production. In the absence of these conditions, an abnormality in tear drainage is the most likely cause.

Deficiencies of tear drainage may be functional or anatomical. Functional failure is related to eyelid malposition (entro- or ectropion, centurion syndrome) and/or poor lacrimal pump function due to lid laxity or orbicularis weakness (e.g. age-related or VIIth cranial nerve palsy).

Anatomical obstruction can develop at any site along the lacrimal drainage pathway. Proximal blocks may be seen in congenital agenesis or acquired stenosis of puncta or punctal plugs/cauterization for treatment for dry eyes.

Acquired nasolacrimal duct obstructions (NLDO) can be differentiated into primary and secondary. Primary NLDO (PANDO) occurs predominantly in middle-aged females. The reason for this is probably the narrower built of the NLDO in females and hormonal changes associated with menopause.

Secondary NLDO (SANDO) can be due to infectious, inflammatory, neoplastic, traumatic, and mechanical causes. Bacteria such as *Actinomyces*, *Propionibacterium*, *Fusobacterium*, *Bacteroides*, *Mycobacterium*, *Nocardia*, *Enterobacter*, *Treponema pallidum*, *Staphylococcus aureus*, and *Chlamydia* species have been associated with lacrimal drainage obstruction. Viral causes are Herpes simplex, Herpes zoster, chickenpox, and adenovirus keratoconjunctivitis. Fungal causes of NLDO are *Aspergillus* and *Candida*. They cause obstruction due to formation of casts or dacryoliths. Parasitic obstruction is rare but is reported in patients infected with *Ascaris lumbricoides*, which enters the lacrimal system through the valve of Hasner.

Inflammatory diseases such as Wegener granulomatosis and sarcoidosis, and also cicatricial pemphigoid, histiocytosis, and scleroderma, can cause NLDO secondary to

chronic inflammation and scarring of the duct mucosa. Chronic use of eye drops (as in glaucoma), systemic chemotherapy, radiation, and bone marrow transplantation are exogenous causes of secondary inflammatory NLDO.

Neoplasms may cause NLDO by primary growth if arising from the nasolacrimal drainage system mucosa. Secondary obstruction can be due to neoplasms extending into the nasolacrimal duct arising from the lids (basal cell, sebaceous, or squamous carcinoma), the maxillary antrum, and the nasopharynx.

Trauma may be iatrogenic in the case of scarring of the lacrimal passage after overly aggressive lacrimal probing or following orbital, craniofacial, or nasopharyngeal procedures. Non-iatrogenic traumatic causes are either blunt or sharp and may be associated with midfacial fractures involving the bones of the nasolacrimal duct. Naso-orbito-ethmoidal fractures are an important cause of traumatic NLDO with telecanthus.

Mechanical lacrimal drainage obstructions may be due to intraluminar foreign bodies, such as dacryoliths or casts, or may be caused by external compression from rhinoliths, nasal foreign bodies, or mucoceles. Rare causes are rhinosporidiosis and lacrimal sac tumors.

Nasolacrimal duct obstruction can be a cause for persistent watering, chronic dacryocystitis with mucous discharge, and acute dacryocystitis. Accurate diagnosis is the prerequisite for adequate management of these cases.

EVALUATION OF EPIPHORA

History

The patient's main symptoms will be epiphora, mucoid, or purulent discharge and/or a (recurrent) painful red swelling in the area of the medial canthus or a persistent non-tender swelling in case of a mucocele.

Past ocular history to be elicited includes previous lacrimal surgery (dacryocystorhinostomy or dacryocystectomy), lid surgery, use of chronic antiglaucoma, or other topical medications, previous acute dacryocystitis, as well as previous conjunctivitis.

Past medical history might yield lymphoma, Wegener granulomatosis, sarcoidosis, ocular cicatricial pemphigoid, scleroderma, trauma to midface, systemic chemo- or local radiotherapy, as well as previous nasal or sinus surgery.

CLINICAL EXAMINATION

General inspection

Examination of the adnexa should include tear film height, matting of lashes, lid position, and (occult) lid laxity (snapback test, pinch test, lateral, and medial canthal tendon laxity). The medial canthal region is to be examined for scars from previous surgeries or trauma as well as any present swellings. Position of the swelling with respect to the medial canthal tendon, overlying skin and signs of inflammation, presence of a fistula, and tenderness should be noted.

Slitlamp examination

Functional causes for epiphora such as blepharitis/meibomitis, lid-globe malapposition (as in Centurion syndrome) foreign bodies, conjunctivochalasis, acute conjunctivitis, or intraocular inflammation are ruled out. The punctal position and configuration are inspected, and pouting of the puncta suggests canaliculitis. Forniceal scarring or shortening might give a diagnostic clue for previous adenoviral conjunctivitis or ocular pemphigoid, and the lid margin is evaluated (keratinization, trichiatric lashes, entro/ectropion).

Schirmer's test for stimulated and basal tear secretion as well as tear film breakup time is done to rule out pathologies of tear secretion and composition which may lead to epiphora.

A regurgitation of mucoid or mucopurulent fluid on pressure over the lacrimal sac area (*regurgitation test* or *ROPLAS*) is indicative of an obstruction in the lower lacrimal drainage system, e.g. the nasolacrimal duct with accumulation of mucous in the lacrimal sac.

Syringing findings suggestive of an NLDO are delayed regurgitation through the opposite punctum (superior, if syringing is done from the inferior one) which may be total or partial and may have stands or flakes of mucoid or mucopurulent fluid. Pressure over the sac area as well as syringing should be avoided in cases of acute dacryocystitis. This is because of the pain and discomfort to the patient as well as spread of the infection and limited diagnostic value. The inflamed and edematous tissues may give a false-positive finding on syringing.

Classically, NLDO with chronic dacryocystitis will give positive results for the ROPLAS test as well as for the syringing. The finding of a positive regurgitation on pressure over the lacrimal sac in combination with a patent nasolacrimal duct (NLD) on syringing is consistent with the diagnosis of an atonic sac or sump syndrome following dacryocystorhinostomy. Syringing findings suggestive of a complete NLD block in combination with a negative regurgitation sign is seen in cases of shrunken sac, encysted mucoceles with intact Rosenmüller's valve but can also be found in tumors of the lacrimal sac.

The *fluorescein dye disappearance test* (DDT) is to evaluate for lacrimal drainage failure. Its main disadvantages are the inability to differentiate between a functional or anatomic obstruction or a pump failure as well as to ascertain the level of obstruction. Fluorescein dye is instilled into the inferior fornix and evaluated under the slitlamp for residual dye present 5 min after instillation. The test

is effective as a screening tool, especially in children with suspected NLDO who are uncooperative for syringing.

The *Jones dye tests* are to sequentially diagnose an obstruction in the nasolacrimal drainage system. For Jones I, fluorescein dye is instilled in the patient's eye, and the patient is asked to blow his nose after 5 min. Presence of dye indicates a patent system and normal physiologic function.

Absence of dye can have three reasons: false-negative result, physiologic dysfunction, or anatomic obstruction. To ascertain the level of the obstruction, the Jones II test is performed. The patient's lacrimal drainage system is irrigated after a negative Jones I, and the patient is asked to expel any drainage from his or her pharynx. Presence of dye indicates a partial block at the lower sac or duct. Absence of dye in combination with the syringing findings is suggestive of a complete NLDO.

In the *Hornbliss saccharine test*, saccharine drops are instilled in one eye and chloramphenicol eye drops in the other eye several minutes later. The ability of the patient to detect the sweet taste of the saccharine and the bitter taste of the chloramphenicol denotes a patent lacrimal system.

LABORATORY INVESTIGATIONS

The discharge can be sent for further investigations depending on the suspected etiology, such as Gram, Giemsa, or KOH staining (for suspected bacterial or fungal infections) and bacterial or fungal culture with antibiotic sensitivity.

IMAGING STUDIES

X-ray of the orbit and paranasal sinuses can be useful in the setting of posttraumatic NLDO. Conventional dacryocystography (DCG) is performed by injecting a radiographic contrast material into the lacrimal drainage passageways with a cannula. There are oil-based and water-based contrast materials. The former will give better contrast and accuracy of imaging; care has to be taken to avoid extravasation which will lead to severe and prolonged inflammation. The patency of the passage can be judged. Circumscribed filling defects can indicate dacryoliths or tumors.

More detailed information can be obtained from a computed tomography (CT) of the orbit and paranasal sinuses, if needed with dacryocystography (CTDCG). Indications for CT imaging in the setting of an acquired NLDO are posttraumatic cases as well as suspected secondary NLDO due to mass lesions, such as neoplasms.

The role for magnetic resonance imaging (MRI) is limited because of the lack of depiction of bony structures, but can be useful in the further differentiation of soft tissue masses.

MEDICAL MANAGEMENT

In acute dacryocystitis, the first line of treatment is the administration of oral or, in severe cases, intravenous

antibiotics in order to prevent orbital cellulitis and/or septicemia. The antibiotic regimen should cover Gram-positive as well as Gram-negative organisms. The underlying cause, the NLDO, has to be surgically treated once the acute infection has been managed. Endonasal endoscopic dacryocystorhinostomy can be considered in cases of acute dacryocystitis. External dacryocystorhinostomy is to be avoided in the acute phase due to the high probability of later wound healing problems and fistula formation. Any lacrimal abscess can be incised as an outpatient procedure.

NLDO due to fungal infection will need surgical debulking as well as systemic antifungal treatment.

SURGICAL MANAGEMENT

The principle of surgical management of a nasolacrimal duct obstruction is to create a passage from the lacrimal sac into the nasal cavity, thereby bypassing the obstruction situated most commonly in the middle and lower nasolacrimal duct. This procedure is termed dacryocystorhinotomy (DCR).

There are several approaches to DCR. The external DCR is the 'gold' standard, in comparison to which the other developments are evaluated. Through a skin incision over the medial canthal region the lacrimal fossa is identified and a bony ostium created, through which the lacrimal sac and the nasal mucosa are anastomosed. In endonasal DCR, the area of the sac is identified by nasal endoscopy, a bony ostium is again created, and the medial wall of the lacrimal sac excised. This approach has the advantages of leaving the medial canthal anatomy and the lacrimal pump function undisturbed as well as avoiding a skin incision with subsequent scar. The incidence of intraoperative bleeding is lower than in the external approach. Concomitant nasal pathology can be dealt with in the same sitting (e.g. septoplasty, poly-removal, turbinectomy) and this approach is suitable for acute infections. On the other hand, it needs specialized instrumentation and training, and the success rate is reported slightly lower than in external DCR, depending on the experience of the surgeon. Newer developments are the transcanalicular DCR and the assistance of endonasal and transcanalicular approaches with radio-frequency devices or lasers and the use of antimetabolites in external and endonasal DCR.

External DCR

Local anesthesia is given to the nasal mucosa with Lignocaine spray and subsequent packing with ribbon gauze soaked in 2 mL of 0.1% (0.05% in pediatric cases) Xylometazoline (Otrivin®) with 2% Lignocaine (Xylocaine®). This will serve analgesia as well as hemostasis of the nasal mucosa. The surgery can be performed in general or local anesthesia. In adults, local anesthesia with sedation is preferred since during extubation positive pressure can lead to hemorrhage. A regional nerve block with 2% Lignocaine with 1:200,000 Epinephrine + 0.5% Bupivacaine (Marcaine®) is given to the infraorbital as well as the supratrochlear nerve and local infiltration is administered to the incision site above the medial

canthal region, again mainly for hemostasis. The incision is made through skin in a slightly curved line 3 mm medial to the medial canthus starting from the level of the medial canthal tendon infero-medially and avoiding the angular vessels. Blunt dissection of the orbicularis fibers is done and the medial canthal tendon (MCT) and anterior lacrimal crest are exposed. The overlying periosteum is incised and reflected laterally along with the lacrimal sac to expose the lacrimal fossa. The osteotomy is initiated at the junction of the maxillary and the lacrimal bones in the depth of the fossa and enlarged with bone punches to a size of about 2 × 1.5 cm. The nasal mucosa is infiltrated with 2% Lignocaine with 1:200,000 Epinephrine. The puncta are dilated and a probe is placed into one or both canaliculi to tent the lacrimal sac. An H-shaped incision is made into the sac along the entire length to achieve an anterior and a posterior flap. The posterior flap may be excised at this stage or retained for anastomosis. Anastomosis of the posterior flaps is done prior to any silicone intubation, followed by the suturing of the anterior flaps with an absorbable suture. The skin can be closed with non-absorbable (6-0 nylon/prolene) sutures.

Endonasal DCR

Endoscopically guided endonasal DCR can be one under local or general anesthesia. Following nasal packing with ribbon gauze soaked in 2 ml of 0.1% (0.05% in pediatric cases) Xylometazoline (Otrivin®) with 2% Lignocaine (Xylocaine®), nasal endoscopy is done and the ostium site viewed (anterior to the middle turbinate). A thin, flexible light source (such as used in vitrectomies) can be passed through the punctum and canaliculus into the lacrimal sac. The glow can be viewed during endoscopy and act as guideline where to initiate the ostium. Any associated nasal pathology can be corrected before starting the actual procedure, e.g. septoplasty or turbinectomy. The ostium site is infiltrated with 2% Lignocaine with 1:200,000 Epinephrine. The mucosa is incised and removed to expose the underlying bone of the lacrimal fossa and the osteotomy is made. The lateral wall of the lacrimal sac can be visualized by applying pressure from externally. The sac is then incised and the lateral wall excised. A silicone intubation can be done if indicated. At the end of the surgery, a nasal pack is inserted. Regular follow-up with nasal endoscopy and irrigation is mandatory in the follow-up period.

Modifications

The success rate of standard external DCR is approximately 80–97% and that of conventional endoscopic DCR is 75–95%. There are several modifications through which the success rate (patency of the anastomosis) can be increased. The use of antimetabolites is one of these measures. The drugs used are Mitomycin C (0.05–0.4 mg/mL; 2–5 min topical intraoperative application onto nasal mucosa) and 5-fluorouracil (2.5–5.0 mg/mL; 5 min intraoperative topical application onto nasal mucosa or as 2.5–5.0 mg (0.5 mL) injection into nasal mucosa). Several studies have demonstrated the increase

in success rate (95.5–97.8%) as well as a larger ostium size following external DCR with MMC.

Radiofrequency devices that reduce the bleeding from the nasal mucosa during incision can assist endonasal DCR. The incision into mucosa and sac are made with the device.

For laser-assisted endonasal (and transcanalicular) DCR, there are several lasers available. The KTP (potassium-titanyl-phosphate) laser is characterized by its high energy, which makes it suitable for osteotomy. Due to the high energy, there is a high incidence of scarring due to thermal injury. The KTP laser has only been used in few studies. The diode laser has enough energy for performing or aiding in the osteotomy and produces minimal thermal injury. Other lasers used in DCR are the Erbium, Neodym and Holmium:YAG lasers. Their energy is not sufficient for osteotomy. Surgery can be done with minimal scarring. The lasers are mainly used for opening of stenoses in failed DCRs as well as in canalicular stenoses.

Newer developments

Transcanalicular surgery and microendoscopic lacrimal surgery are the current developments. Transcanalicular DCR can be performed with or without endoscopy. The diameter of canaliculi in adults is approximately 1 mm. Soft-tissue stenoses following failed DCR can be opened by microdrills or lasers, introduced via a flexible probe. For creating the osteotomy in DCR, the microdrills are not powerful enough, hence KTP or diode lasers can be used. The success rate has been reported as 88–95%.

Diagnostic microendoscopy can be performed with a flexible canalicular endoscope (0.5–0.7 mm), inserted into a modified Jünemann-probe (0.9 mm). The nature and location of the stenosis can be evaluated this way. The quality of the picture has reached 3000–6000 pixels. Apart from diagnostics, endoscopy can be combined with transcanalicular procedures using a probe with one or two additional ports for irrigation and instrumentation.

Transcanalicular DCR can again be combined with anti-metabolites or balloon dacryoplasty as well as endonasal approach.

Dacryocystectomy (DCT)

DCT involves the removal of the lacrimal sac as well as nasolacrimal duct. Limited DCT is the removal of the sac only. The main indication for performing a DCT is suspected lacrimal sac malignancy. But chronic infections, such as in rhinosporidiosis, tuberculosis and actinomycosis, and chronic inflammatory conditions, such as Wegener's granulomatosis, are reasons for performing a DCT instead of a DCR in the setting of a nasolacrimal duct block. In these cases, the chance of reactivation of the disease through the surgery is high. DCT can also be indicated in cases of NLDO with dry eyes as in ocular pemphigoid in which the chances of postoperative epiphora are minimal. DCT takes less time than a DCR and chances of hemorrhage are much less. It can be performed under local anesthesia without sedation since no

osteotomy is performed. This makes the procedure suitable in elderly, frail individuals who have a high risk for local anesthesia with sedation due to their medical conditions, especially if the main complaint is chronic or recurrent dacryocystitis rather than epiphora. In elderly patients, the basal tear production is reduced so that the patient may have minimal or no epiphora following surgery.

The procedure is begun as the standard DCR. The medial canthal tendon is visualized and cut to expose the fundus of the sac. Any adhesions are dissected and the sac freed. If malignancy is suspected, a biopsy can be taken for frozen section from the sac or the surrounding tissue. The sac is then bluntly dissected inferiorly up to the nasolacrimal duct and cut at the level of the common canaliculus. In case of malignancy, the bony canal can be removed. The sac is grasped and twisted until it is freed completely and sent for histopathological analysis. The wound is closed after ensuring hemostasis.

Summary

Acquired nasolacrimal duct obstruction is a common cause for epiphora and can be the underlying condition for acute and chronic dacryocystitis. There are numerous causes including degenerative, infective, and malignant conditions. Thorough history and investigation is mandatory for planning of the appropriate management. There are various clinical tests to confirm the diagnosis of an NLDO and imaging has a role in certain conditions. Surgical management is essentially dacryocystorhinostomy. External or endonasal DCR are the standard procedures, whereas transcanalicular and microendoscopic as well as laser-assisted DCR belong to the newer developments. Suspected malignancy is a contraindication for DCR surgery, and dacryocystectomy should be performed in these cases.

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Visual impairment among children with multiple disabilities

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INTRODUCTION

Seventy-five to ninety percent of our understanding about the world comes through our eyes.¹ A child's vision is a learned and developed skill that requires stimulation and experience.² The effect of visual impairment on learning and development when the child also has an impairment in another area of functioning such as sensory, motor, emotional, intellectual and/or in any combination can be devastating. For children with motoric delays such as cerebral palsy, the access to the larger world that they cannot physically reach and explore is largely through their eyes. For children with mental retardation, where language processing is often a challenge, visual feedback gives them an important additional way to make sense of the world.

World Health Organization (WHO) estimates that over 16 million people have locomotor disabilities, including cerebral palsy, and 3.2 million have hearing impairment, and 3% of Indian children are mentally retarded (WHO, 1991). Studies around the world have documented higher incidence of visual impairment, particularly among those with developmental disabilities such as cerebral palsy and mental retardation.²⁻⁵

In India, among children with cerebral palsy, the more visible motor and health issues take precedence in intervention, and visual issues are often overlooked.³ Early diagnosis and effective intervention can significantly reduce the incidence and negative developmental impact of visual impairment in this population. The aim of the present study was to determine the visual status of children with multiple disabilities.

MATERIALS AND METHODS

All sixty children with multiple disabilities from National Institute for Empowerment of Persons with Multiple Disabilities in Chennai, Tamilnadu, were included in the study. The study was done from July 2009 to November 2009. Of the sixty children, 54 could undergo the screening tests, and the remaining six could not attend. Demographic data on age, gender, and combination of disabilities, birth history and family history were recorded. Complete clinical and functional assessment and visual rehabilitation were done in all cases. Clinical

assessment included visual acuity testing, cycloplegic refraction, cover test and torch light examination. Functional assessment included visual tracking (from right to left and from left to right), scanning (both horizontal and vertical), gaze shifting (between two, three, multiple objects), locating and searching for dropped and hidden objects in low and high contrast, clutter performance and object details observation. While performing functional assessment, information was gathered from parents regarding the visual and sensory functioning of the child. A collection of reported visual behaviours such as squinting, light gazing, eye poking, finger flicking, head turning or tilting, closing one eye/eye preference, maximum distance at which the child exhibits visual recognition and optimum lighting conditions was noted. Visual acuity testing was done using Snellen chart. If not responded to Snellen chart, then fixation was tested with torchlight, shiny papers/cloth, $\frac{1}{4}$ -foot-sized white toy with respect to their fixating abilities. The maintenance of fixation is assessed by moving the target away from the child. The farthest distance at which the fixation was maintained was measured. The target fixated, and the farthest distance at which the fixation maintained was recorded as the visual acuity. Glass prescription was given for those who had significant refractive error (hyperopia $> +2.50$ DS, myopia > -0.50 DS and astigmatism > 1.50 D). If torchlight examination revealed any ocular pathology, then the child was referred to Sankara Nethralaya Eye hospital. They were also referred to other rehabilitation services such as early intervention classes, Orientation and Mobility training and Educational guidance if required. Parents were counselled for the constant wear of refractive correction, and vision training for the children which could enhance their functional vision abilities to a larger extent.

RESULTS

Of the 54 children seen, 41 were male and 13 were female. Of these, 26 were in the age group 1–5 years, 11 between 6 and 10 years, 14 between 11 and 15 years, two between 16 and 20 years and one >20 years. Consanguinity was present in 15 cases. Of the 54 seen, 14 had been diagnosed to have single disability, e.g. cerebral palsy, and 40 had combination of disabilities, e.g. cerebral palsy with

Table 1. Disabilities of the study subjects

Condition	Number of subjects
CP with MR and seizure disorder	6
CP with MR	4
Delayed developmental milestones	4
MR	4
CP	3
Seizure disorder, MR	3
MR, ADHD, speech impairment, seizure disorder, poor cognitive abilities	2
DD with speech impairment	2
Others	26

Others include CVI, spinal muscular atrophy, Down's syndrome, microcephaly, HI, respiratory problems, language development impairment, brain injury sequelae, autism, hyperactive, impairment of intellectual functioning and/or combination of any of the conditions.

CP, cerebral palsy; MR, mental retardation; DD, developmental delay; ADHD, attention deficit hyperactive disorder; HI, hearing impairment; CVI, cortical visual impairment.

mental retardation and speech impairment (Table 1). Visual acuity was recorded using Snellen's chart in 10 children, object in 30 and light/shiny papers in 14 children. Among 10 who had using Snellen's chart, eight had their best corrected visual acuity >6/18 and two between 6/18 and 6/60 (Figure 1). Using light and shiny papers, three had fixation to only light and followed it in all directions, two can fixate but unable to follow, six can fix and follow both light and shiny papers and three had no light perception (Figure 2). Of the 30 for whom 1/4-foot-sized white-coloured object was used for recording visual acuity, 15 can follow the object to >3 minutes, three to 2.5-3 minutes, three to 2-2.5 minutes, four to 1.5-2 minutes, three to 1-1.5 minutes and two to 0.5-1 minute.

Table 2 shows the ocular conditions of the study subjects. Functional assessment revealed good tracking abilities in 17%, smooth scanning in 16%, gaze shift for multiple objects in 16%, better performance for clutter in 18%, fine detail observation in 17%, and locate objects in both high and low contrast in 18%.

Glass prescription was given for six children, 15 children were referred to Sankara Nethralaya for further examination and three were referred to orientation and mobility training (Figure 3). Of the 15 who were referred, three had cataract, two had micro-cornea, one had microphthalmus, five had large-angle strabismus, one with muscle restriction and three had optic atrophy.

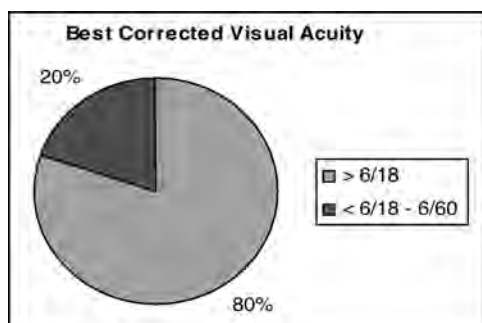


Figure 1. Best corrected visual acuity of 10 children recorded with Snellen chart.

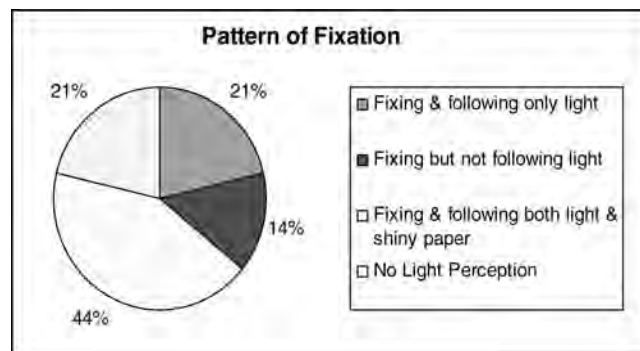


Figure 2. Patterns of fixation of 14 children recorded with light/shiny paper.

DISCUSSION

Two-thirds of the functions of the brain are associated with vision. In multiple disabled children who often have some form of cerebral ischaemia, vision can be grossly affected. A study by Britto et al.² on visual status of children with multiple handicaps of age group 0-15 years in southern India showed that 51.2% had visual impairment co-existent with other disabilities and 26% had refractive errors. Another study by Mervis et al.⁵ reported that incidence of visual impairment in US population was co-exist with other impairments in two-thirds (66.6%) of their cases. In the present study, visual impairment was co-exist with other disabilities in 56% cases, and refractive errors were seen in 38% cases. A study done by Jacob et al.³ on visual conditions among children with developmental disabilities in southern India found that 72% children are with visual impairments in addition to other impairments. The five most common causes of visual impairments among this group were optic nerve atrophy, cortical visual impairment, delayed visual maturation, congenital cataracts and myopia, and these conditions occurred most frequently along with cognitive disorders, cerebral palsy and seizure disorders.

Table 2. Ocular diagnosis of the children

Ocular diagnosis	Number of children
Normal	19
Refractive error*	9
Strabismus*	
Esotropia	7
Exotropia	2
Alternating esotropia	3
Alternating exotropia	1
Optic atrophy*	4
Cataract	3
Micro cornea*	2
Microphthalmus	1
Nystagmus*	5
Muscle restriction	3
Not known	6

*Nine children had combination of ocular conditions: refractive error and strabismus, strabismus and nystagmus, strabismus and optic atrophy, nystagmus and optic atrophy refractive error and micro-cornea and optic atrophy with nystagmus and refractive error.

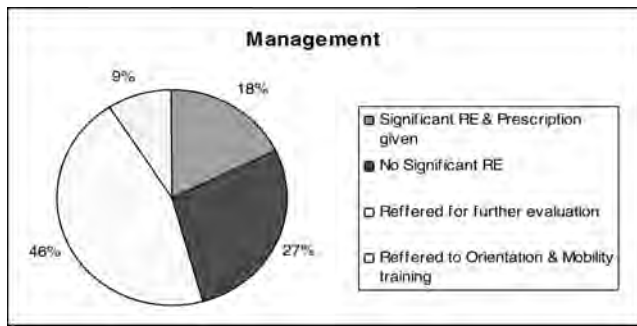


Figure 3. Management given for the children.

CONCLUSION

Children with multiple disabilities will undergo rehabilitation in concept development, motor development, daily living skills and other tasks, all of which require good visual function. The existence of visual problems such as strabismus, refractive errors, is often overlooked, among these children, which can delay rehabilitation. So, there is an urgent need to develop professional capacity to assess vision and interventions for these children. They represent a significant percentage of the population of children who have visual impairments.

The close cooperation between the parents, staff of training programmes and the eye care services helps the children to a greater extent in the enhancement of functional vision.

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Biologics in uveitis

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INTRODUCTION

Uveitis is known to be a spectrum of diseases, which have a great potential for visual morbidity and visual loss.¹ In terms of our armamentarium against uveitis, immunosuppressive medications, such as corticosteroids and steroid-sparing immunomodulatory agents, have been the mainstay of treatment. They have demonstrated efficacy in the treatment of uveitic syndromes, but side effects often limit their use.

WHAT ARE BIOLOGICS?

Biologics, or 'biologic response modifiers' as they are better known as, are a new class of medications that form an alternative treatment option for the management of treatment-resistant, sight-threatening and refractory uveitis.² These are produced by means of biological processes involving recombinant DNA technology, and they comprised of recombinant cytokines and monoclonal antibodies directed against selected cell-surface markers. Biologics have shown promise in the treatment of uveitis and ocular inflammatory diseases and are especially helpful for patients who are either unresponsive to or have experienced harmful side effects from other conventional treatments.

MODE OF ACTION

Some biologics act against the proinflammatory chemokines (tumour necrosis factor, interleukins 1, 2, 6 and interferon gamma) and their receptors, whereas others counteract with the secretions of these chemokines, T-cells and B-cells, thereby aiming to preventing the down cascade of inflammation.

CLASSIFICATION

The various biologics fall under the following groups:

- Tumour necrosis factor- α inhibitors
 - Infliximab (Remicade)
 - Etanercept (Enbrel)
 - Adalimumab (Humira)
- Interleukin-2 receptor blocker
 - Daclizumab (Zenapax)
 - Anakinra
- Antilymphocyte drugs
 - Rituximab
 - Alemtuzumab
- Recombinant interferon- α (Avonex).

Tumour necrosis factor- α inhibitors

The anti-TNF agents—Infliximab, Etanercept and Adalimumab—have been used to treat resistant uveitis. In particular, Infliximab and Adalimumab have shown significant efficacy in refractory ocular Behçet's disease and refractory idiopathic posterior uveitis. They have also been proved useful in controlling uveitis associated with seronegative spondyloarthropathies and juvenile idiopathic arthritis. However, as of now, the efficacy of only these two monoclonal antibodies has been proved. There have been reports of occurrence of inflammatory eye disease iatrogenically by Etanercept.

Infliximab

At present, Infliximab is the most commonly used biologic for the treatment of uveitis.³ It is a chimeric monoclonal human–murine antibody and it is usually given concomitantly with a second agent, such as azathioprine or methotrexate, to reduce the risk of antibodies developing against the medication itself. It has been used in children with non-infectious uveitis and in adults with posterior uveitis especially with Behçet's disease associated posterior uveitis. It is administered as an intravenous infusion at a dose of 3–10 mg/kg. The response to Infliximab is, however, temporary and so the dose and frequency of infusions have to be varied depending on the clinical response.

Reported side effects:

- Increased risk of tuberculosis, malignancy
- Optic neuritis
- Drug-induced lupus.

Etanercept

Etanercept is a genetically engineered fusion protein of TNF receptor p75. It has the ability to bind to soluble TNF- α and TNF- β , thus blocking binding to cell-surface TNF receptors. It is administered subcutaneously at the dose of 25 mg twice a week. Etanercept neither appears to protect against the onset of uveitis nor prevents

relapses of uveitis. On the contrary, there have been reports suggesting that it may induce uveitis.⁴

Reported side effects:

- Nausea, vomiting
- Headache
- Cough
- Difficulty breathing
- Rash
- Tingling of the hands or feet
- Chest pain
- Unsteadiness
- Muscle weakness.

Adalimumab

Adalimumab is a recombinant, fully humanized IgG₁ monoclonal antibody that binds specifically to TNF- α and blocks interaction with the p55 and p75 cell-surface receptors. It may be more effective in suppressing inflammation than Etanercept. It can be self-administered subcutaneously by the patient and is given at 2-week intervals at a dose of 40 mg. Its adverse effects are similar to those of Infliximab.

Interleukin-2 receptor blockers

Interleukins form a part of the family of cytokines and regulate the growth and function of lymphocytes. Thus, interleukin receptor blockers specifically prevent T-cell activation and proliferation.

Daclizumab

Daclizumab is a recombinant, humanized monoclonal immunoglobulin of the IgG₁ isotype, composed of 90% human and 10% murine antibody sequences that acts as an IL-2 receptor antagonist and inhibits IL-2-mediated responses of activated lymphoid cells. It was shown to be effective in treating S-antigen-induced experimental autoimmune uveitis in non-human primates. Daclizumab has been reported to be successful in the modulation of intermediate and posterior disease even in refractory cases.⁵ It is given weekly as intravenous infusions at the dose of 1 mg/kg. Subcutaneous injections of Daclizumab at the dose of 2 mg/kg have also been tried and found to be well tolerated.

Anakinra

Anakinra is a recombinant IL-1 receptor antagonist and has shown promising results in murine models of autoimmune uveitis. Studies have shown Anakinra to improve inflammation in cases of uveitis associated with Behçet's disease.⁶ It is administered as a subcutaneous injection of 100 mg daily.

Antilymphocyte drugs

Rituximab

Rituximab is a chimeric mouse-human monoclonal antibody against CD20, a B-cell antigen. Studies have shown its positive results in the treatment of anterior uveitis.⁷ Rituximab is given by intravenous infusion.

Reported side effects:

- Immune toxicity
- Reactivation of infections

- Cardiac arrest
- Progressive multifocal leukoencephalopathy.

Alemtuzumab

Alemtuzumab is an all-human monoclonal antibody which targets CD52, an antigen present on the surface of mature lymphocytes. There have been reports of remission in Behçet's disease on treatment with Alemtuzumab.⁸ It is administered as intravenous infusion for a period of 5 days.

Reported side effects:

- Increased risk of opportunistic infections.

INTERFERONS

Interferons are immunomodulating cytokines produced in response to viral infections. They have antiviral, anti-proliferative and anti-angiogenic properties.

Depending upon their structure and biologic properties, interferons are classified into two types:

- Type 1 interferons
- Type 2 interferons

with α and β subgroups.

Recombinant human IFN- α has been used with success to treat posterior uveitis associated with Behçet's disease, Vogt-Koyanagi-Harada disease, serpiginous choroiditis, birdshot chorioretinopathy and idiopathic causes.⁸ It is given initially in the dose of 3–6 million IU per day. Then the dose is reduced to 3 million IU twice weekly stepwise over months and finally stopped.

The side-effect profile of biologics is quite varied. Because of the potential for side effects, caution must be exercised while using these agents. Treatment of patients with ocular inflammatory disease must be individualized and regularly monitored.

Reported side effects:

- Flu-like symptoms
- Leukopenia
- Depression
- Alopecia
- Elevated hepatic enzymes
- Drug-induced lupus.

CONCLUSION

Biologicals are a relatively new class of medicines that represent a useful therapeutic adjunctive group for treating recalcitrant childhood uveitis and have increased the treatment options for sight-threatening uveitis. As it stands today, biologics are proving to be the new frontiers in the armament of tackling uveitis. Highly targeted biologic therapies are emerging as promising new treatment options for sight-threatening uveitis and cases refractory to conventional immunosuppression. But, caution has to be practiced in their use as they have their own potential risks, some of which are quite serious. The pros and cons of their use, the serious and unanticipated complications and the high cost of these agents must have all to be taken into consideration.

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Muscle puzzle

R. Sowmya and Sumita Agarkar

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Nineteen years old female patient presented to us with C/o squinting of right eye noticed since the age of 7 months. No h/o worsening of squint since then.

On examination, her visual activity was OD 6/6 (C.0.75 DS/-0.50 DC 50°) N₆; (OS) 6/36 N₆. She had chin elevation. Examination revealed (OD) ptosis and habitually fixed with the same eye. Anterior segment and dilated post-segment examination were normal in both eyes.

The ocular motility and alignment were as seen in the photographs below.

Patient has (OD) monocular elevation deficiency. She habitually fixates with OD, thus has large secondary deviation (OS; large LHT in primary gaze). This habitual fixing with right eye has led to suppression in left eye.

Differential diagnosis for limitation of elevation include

(a) Brown's syndrome:

- Limitation of elevation more in adduction.
- Chin up and contralateral face turn may be present.
- FDT positive (up and in).
- 'V' pattern present (no superior oblique overaction).

(b) MED:

- Limitation of elevation is both in adduction and abduction.
- It may be due to SR paresis/IR restriction and needs to be differentiated for appropriate surgical

planning. It can also be due to supranuclear etiologies.

- It can be associated with hypotropia and ptosis/pseudoptosis. This association is attributable to common embryological origin of LPS and SR.
- The presence of hypotropia in primary gaze with ptosis goes in favour of SRpalsy. Further longstanding SR palsy can have secondary IR restriction.
- Upward saccades and FDT helps in differentiating them.

Other conditions:

- Vertical Duane syndrome;
- Third cranial nerve palsy;
- Congenital fibrosis of IR muscle.

Options for management include a staged procedure:

- ✓ Ipsilateral IR recession is done if FDT is positive.
- ✓ Knapp's procedure (vertical transposition of horizontal rech.) if FDT is negative. Partial or a full tendon Knapp's can be done depending on the amount of hypertropia in primary gaze. Foster modification (posterior fixation suture of transposed muscles to sclera adjacent to SR) is preferred to correct larger deviation.

The course of management in this pt. was (OD) IR recession 3.5 mm with (OS) SR recession 5 mm+IR resection 4 mm. Surgery was performed in (OS) because of large secondary deviation and preference of right eye for fixation.



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Introduction to biostatistics-4

Correlation analysis

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INTRODUCTION

Correlation analysis is a statistical technique that evaluates the relationship between two or more variables, i.e., how closely they match each other in terms of their individual mathematical change. For example, if one variable (X) moves or changes in a certain direction, then the second variable (Y) also moves or changes in a similar or complimentary direction.

TYPES OF CORRELATION

There are two important types of correlation. They are:

1. positive and negative correlation and
2. linear and nonlinear correlation.

Positive correlation

If the values of the two variables deviate in the same direction, i.e., an increase (or decrease) in the values of one variable results, on an average, in a corresponding increase (or decrease) in the values of the other variables. For example:

- (a) heights and weights and
- (b) smoking and lung cancer.

Negative correlation

If the values of the two variables deviate in opposite direction, i.e., an increase in the value of one variable results in a decrease in the value the other variable. For example:

- (a) insulin and blood sugar level and
- (b) price and demand.

Linear correlation

The correlation between two variables is said to be linear if it is corresponding to a unit change in one variable, and

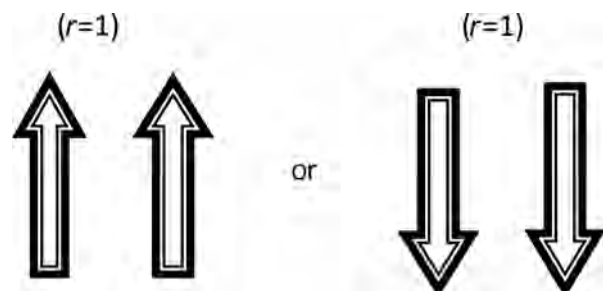
there is a constant change in the other variable over the entire range of the values.

Nonlinear correlation

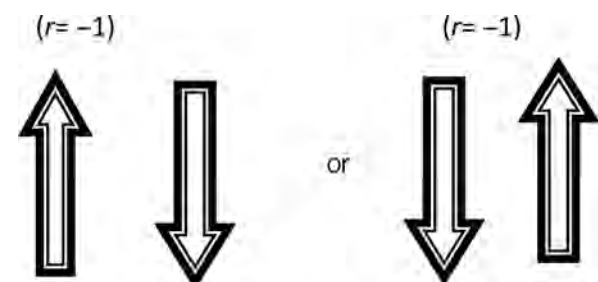
The relationship between two variables is said to be nonlinear or curvilinear if it is corresponding to a unit change in one variable, and the other variable does not change at a constant rate but at a fluctuating rate. When this plotted in the graph, this will not be a straight line.

Correlation coefficient (r) is a measure of strength and direction of the relationship between two or more variables. It ranges from -1 to $+1$. Negative values indicate that the two variables are negatively correlated. Positive values indicate that the two variables are positively correlated. Zero (no) correlation indicates that there is no relationship between the variables.

Positive correlation:

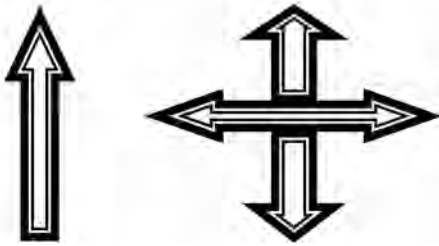


Negative correlation:



No correlation:

$(r = 0)$



METHODS OF MEASUREMENT OF COEFFICIENT OF CORRELATION

The various methods of measuring simple correlation are as follow.

1. Karl Pearson's coefficient of correlation

It measures the strength and direction of the linear relationship between two variables. The data of the variable should be in ratio or interval scale. It is denoted by r , ranging from -1 to $+1$.

CLASSIFICATION OF CORRELATION

- (a) *Simple correlation.* Simple correlation concerns with related variation among two variables.
- (b) *Multiple correlation.* In multiple correlation, three or more variables are studied simultaneously.
- (c) *Partial correlation.* In partial correlation, we consider only two variables influencing each other, whereas the effect of other variable is held constant.

Assumptions in calculating the Karl Pearson's correlation coefficient

- (a) Observations should be independent of each other.
- (b) Variables should be normally distributed.
- (c) There should be a cause-and-effect relationship between the correlated variables.
- (d) Variables should be linear, related to each other.
- (e) Both variables (X and Y) are interval or ratio scale.

Table 1. Degrees of correlation

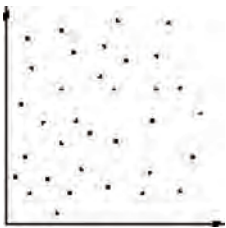



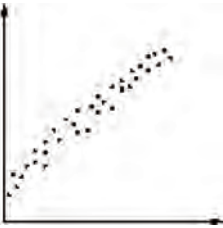

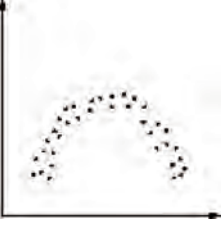
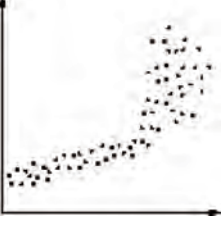
Scatter diagram	Degree of correlation	Interpretation
	None	No relationship can be seen. The 'effect' is not related to the 'cause' in any way.
	Low	A vague relationship is seen. The 'cause' may affect the 'effect', but only distantly. There are either more immediate causes to be found or there is significant variation in the 'effect'.
	High	The points are grouped into a clear linear shape. It is probable that the 'cause' is directly related to the 'effect'. Hence, any change in 'cause' will result in a reasonably predictable change in 'effect'.
	Perfect	All points lie on a line (which is usually straight). Given any 'cause' value, the corresponding 'effect' value can be predicted with complete certainty.

Table 2. Types of correlation

Scatter diagram	Types of correlation	Interpretation
	Positive	Straight line, sloping up from left to right. Increasing the value of the 'cause' results in a proportionate increase in the value of the 'effect'.
	Negative	Straight line, sloping down from left to right. Increasing the value of the 'cause' results in a proportionate decrease in the value of the 'effect'.
	Curved	Various curves, typically U- or S-shaped. Changing the value of the 'cause' results in the 'effect' changing differently, depending on the position on the curve.
	Part linear	Part of the diagram is a straight line (sloping up or down). May be due to breakdown or overload of 'effect', or is a curve with a part that approximates to a straight line (which may be treated as such).

2. Spearman's rank correlation

It is a non-parametric measure of correlation. It is particularly useful when one is looking into the correlation between variables that are not exactly continuous. Spearman's rank correlation test does not assume any assumptions about the distribution. It is used when the Pearson test gives misleading results.

Assumptions

- (a) Does not require any assumptions about the frequency distribution of the variable.
- (b) Does not require the assumption that the relationship between variables is linear.
- (c) Does not require the variable to be measured on interval or ratio scale.

For example, when different judges rank a given performance, Spearman's rank correlation could be used to find the correlation between the different ranks.

3. Kendall tau rank correlation

It is a measure of correlation between two ordinal-level variables. It is most appropriate for square tables.

Kendall's tau is equivalent to Spearman's rank correlation, with regard to the underlying assumptions, but Spearman's and Kendall's are not identical in magnitude, because their underlying logic and computational formulae are quite different. In most cases, these values are very similar, and when discrepancies occur, it is probably safer to interpret the lower value. More importantly, Kendall's tau and Spearman's imply different interpretations. Spearman's is considered as the regular Pearson's correlation coefficient in terms of the proportion of variability accounted for, whereas Kendall's tau represents a probability, i.e., the difference between the probability that the observed data are in the same order versus the probability that the observed data are not in the same order.

Interpretation of Kendall's correlation coefficient

- (a) If the agreement between the two rankings is perfect and the two ranking are same, the coefficient has value 1.
- (b) If the disagreement between the two rankings is perfect and one ranking is the reverse of the other, the coefficient has value -1.

- (c) For all other arrangements, the value lies between -1 and 1 .
- (d) If the rankings are independent, the coefficient has value 0 .

4. Scatter diagram

It is a graphical technique used to analyze the relationship between two variables. It shows whether or not there is a correlation between two variables. Correlation refers to the measure of the relationship between two sets of variables. Two sets of data are plotted on a graph, with the y -axis being used for the variable to be predicted and the x -axis being used for the variable to make prediction.

Use the scatter diagram, when

- one suspects that there is a relationship between two variables,
- the data is continuous, such as temperature, time, age, etc. and

- one needs a fast and easy way to test relationships between variables.

CONCLUSION

In this article, we have dealt with various methods of measurement of correlation between variables in a research study. In general, the two most widely used methods are Karl Pearson's coefficient of correlation and Scatter diagram.

In the next issue, we will discuss about the concept and methods of regression analysis.

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Shivering following a peribulbar ophthalmic anaesthetic block

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Retrobulbar block can cause injury to optic nerve. But even without injury to the optic nerve, inadvertent dural puncture of the optic nerve sheath and injection of local anaesthetic into the optic nerve sheath and into the cerebrospinal fluid space can lead to spreading of local anaesthetic to the various centres in the mid-brain and produce complications depending on the area to which it spreads. Shivering is one of the many complications of retrobulbar block. Since peribulbar block is given away from the optic nerve, this complication is remote in peribulbar block.

There are no reports of shivering following peribulbar block. A rare case of violent shivering following peribulbar block is presented here.

CASE REPORT

Shivering occurred soon after completion of peribulbar block administered for phacoemulsification extracapsular cataract extraction and intraocular lens implantation in the left eye in a 63-year-old female patient. She had no history of allergy to drugs or injections. She had a previous eye surgery in the right eye with no complication.

Pre-anaesthetic evaluation revealed a history of systemic hypertension for the past 2 years and was under control with Amlodipine 5 mg once daily. Her random blood sugar was 150 mg/dL and her blood pressure was 150/90 mmHg on admission and 140/87 mmHg before administering the anaesthetic block.

She was administered peribulbar block with 8 mL of 2% xylocaine with hyaluronidase with 23 G × 1 in. stainless steel needle under monitored care of blood pressure heart rate and pulse oximetry. Soon after block, she complained of being cold and began shivering. She was covered with blanket. She still felt cold and was shivering. A heater blowing hot air under the blanket was kept. When she felt better, she was transferred into the operation theatre. Again she started complaining of severe cold and started shivering severely. Shivering was so severe as to be misjudged as a seizure, but its onset appeared to be slower than a seizure. The patient remained conscious during the episode of shivering. Warming continued.

When shivering lessened and the patient felt better, surgery was started. But during surgery, the blood pressure

rose to 210/114 mmHg and her heart rate rose to 127 bpm. She never lost consciousness. I.V. midazolam 1 mg was given and the patient was made to pass urine. Her blood pressure came down to 160/105 (120) mmHg, and surgery was completed. Post-operative blood sugar was 89 mgm/dL. And her nails and tongue were pale. Twenty-five percent of dextrose IV 20 ml and 100 mg of hydrocortisone IV were given and patient kept warm with heater. After 2 hours when she was completely normal, she was discharged.

DISCUSSION

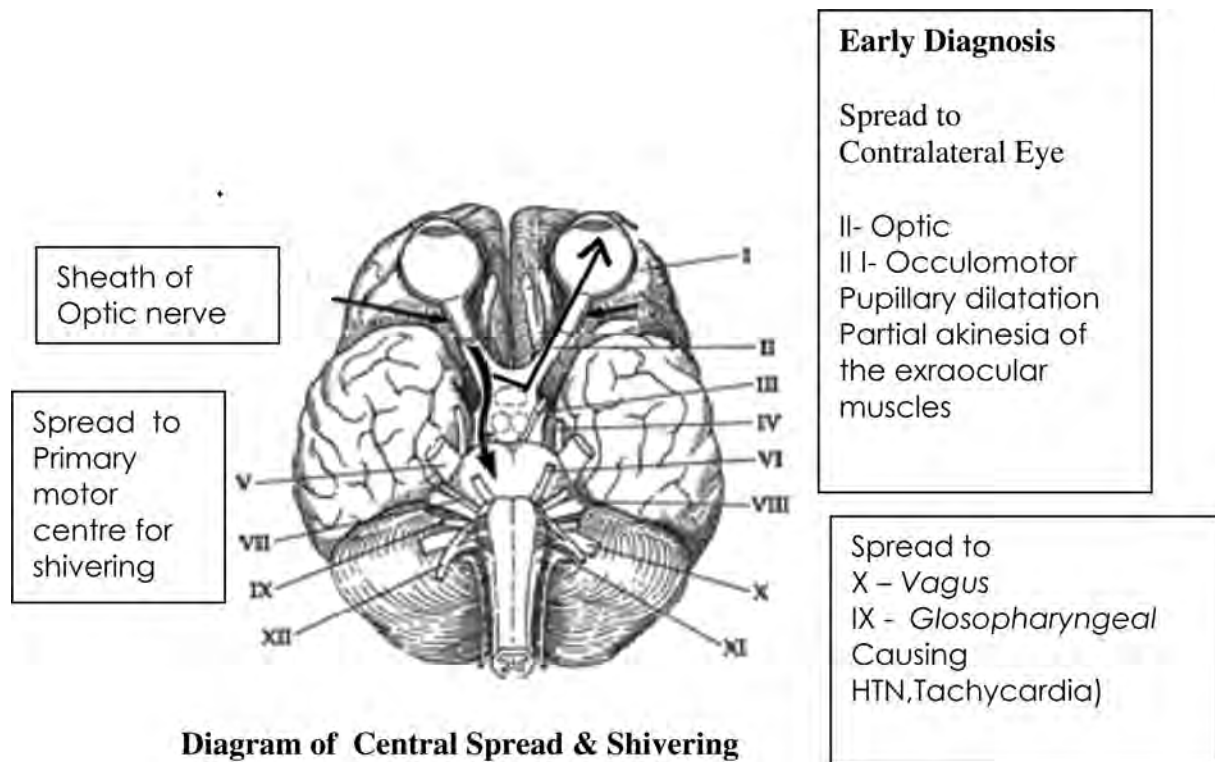
The mechanism of shivering appeared to be the central spread of local anaesthetic solution into the brain stem, along the optic nerve.

Shivering is one of the manifestation of brain stem anaesthesia which may include convulsion, confusion, loss of consciousness, change in blood pressure, heart rate apnoea or change in respiratory pattern, vomiting shivering, hemiparesis, ataxia. Any one of these complications may appear singly or in combination.

The severe shivering observed appeared to have been directly related to central spread rather than the patient's coincidental exposure to a cold environment. The nature of shivering observed in the present case was quite unique. It was so severe as to be misjudged as a seizure. The patient could not understand why she was shivering so severely.

The episode of shivering was probably the result of local anaesthetic solution spreading along the optic nerve sheath and contacting an area of the brain stem linked to the shivering mechanism. Stimulation of this area can produce shivering.⁵ In experiments with animals, local anaesthetic solution applied to the ventro-medial reticular formation of the brain stem facilitates shivering, whereas application to the lateral pontine reticular formation inhibits shivering.^{5,6}

Located in the dorsomedial portion of the posterior hypothalamus near the wall of the third ventricle is an area called the primary motor centre for shivering. It transmits signals that cause shivering through bilateral column of the spinal cord and finally to the anterior motor neurons. These signals are non-rhythmic and do not cause the actual muscle shaking; instead they increase



the tone of the skeletal muscle throughout the body. When the tone rise above a certain critical level, shivering begins.⁷

either due to vagolysis or blockage of the carotid sinus reflex via the glossopharyngeal nerve.³

DIAGNOSIS

Pupillary dilatation and partial akinesia of the extraocular muscles of the contralateral eye may occur with or without any other sign. This sign is pathognomonic of central spread of local anaesthetic agent. This sign should be looked whenever any abnormal reaction occurs following the block.

Hypotension and bradycardia have been observed with brainstem anaesthesia, but more commonly hypertension and tachycardia result.⁴ Hypertension and tachycardia are

CONCLUSION

Many cases previously attributed to vasovagal responses, anaphylaxis, may have been episodes of central spread. Even shivering is usually attributed to cold operation theatres instead of central spread. As more and more anaesthetists are now becoming involved in administering and monitoring local ophthalmic anaesthesia, a greater understanding of these complications should be reached and greater quality of patient care for local anaesthesia patients should be achieved.

Table 1. Peribulbar block—shivering record of vital signs

Time	Blood sugar (mg/dL)	Blood pressure (mm Hg)	Pulse rate (min ⁻¹)	Respiratory rate (min ⁻¹)	SpO ₂ (%)	Remarks
Pre-anaesth. evaluation	RBS 102	140/90	80			
AB ward admission	RBS 150	150/90	82			
Pre-block		146/85	80	16	100	Peribulbar block given
Post-block		153/102	98	16	100	I.V. midazolam
10:39 AM						1 mg given shivering covered with blanket
10:48 AM		136/94	100	19	100	Transferred to OT
10:58 AM		153/102	108	22	100	Shivering
11:10 AM		210/114	127	27	100	HTN tachycardia severe shivering—hot air under blanket
11:14 AM		160/105	113	27	100	
11:25 AM	RBS 85	141/92	115	32	100	I.V. dextrose hydrocortisone

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Technology update

The Femtosecond Laser

Devendra V. Venkatramani

INTRODUCTION

Femtosecond laser is an innovative modification of existing laser technology. Currently it's most common application is corneal flap creation in LASIK surgery; over 30% of all LASIK flaps¹ in the US were made with the femtosecond laser in 2006.

The femtosecond laser is being adapted for use in other corneal and ophthalmic surgeries, and elsewhere in the medical field.

PHYSICS

The femtosecond laser with a wavelength of 1053 nm falls in the near-infrared spectrum, along with the Nd:YAG laser (wavelength of 1064 nm). These are photodisruptive lasers. By a phenomenon called photoionization, they produce 'plasma', a state of matter which is a mixture of free electrons and ions. As the plasma expands, an acoustic shock wave disrupts tissue, yielding cavitation gas bubbles of water and carbon dioxide. These end products eventually diffuse into the surrounding tissues.

The Nd:YAG laser, with a pulse duration in the nanosecond range (10^{-9}), has a large zone of damage of approximately 100 microns. By shortening the pulse duration to the femtosecond (10^{-15}) range, the zone of collateral damage is reduced several times. Thus, the precision with which tissues are disrupted is greatly increased, attaining surgical levels.²

FEMTOSECOND LASER IN LASIK FLAP CREATION

Technique

The patient's eye is positioned and aligned. In the IntraLase system, a low-pressure suction ring (35–40 mmHg) is applied. A flat glass contact lens is then used to appanate the cornea and simultaneously acts as an eyelid speculum. The flap interface is created with the application of laser spots in a raster (zigzag) or centrifugal manner. Vertical side cuts are created to join this interface to the corneal surface. The vertical side cuts allow easier and more precise replacement of the flap onto the stromal bed after the LASIK procedure is complete. A hinge can be left behind at a desired meridian. The flap is elevated by gently sweeping and breaking remaining tissue adhesions with any fine instrument.

ADVANTAGES OVER MICROKERATOME-PRODUCED FLAPS

1. Lesser incidence of flap-related complication, including buttonholes, free caps, epithelial abrasions and flap serrations.³
2. Greater predictability of flap thickness.⁴
3. Ability to cut thinner flaps (90 microns or less) which is of utility in thin corneas and/or high refractive errors.
4. No moving parts, hence fewer sources of error such as short flaps.
5. Greater precision may be associated with less induced aberration.
6. Need for less vacuum in the suction ring may reduce the risk of retinal vascular occlusion.

COMPLICATIONS

1. Opaque bubble layer (OBL)—coalescence of the cavitation bubbles. This may interfere with centration of treatment by hindering the laser tracking devices and the surgeon's view of the pupil.
2. Dissection of bubbles under the epithelium or seepage into the anterior chamber.
3. Transient light-sensitivity syndrome (TSSS)—possibly due to effects of the infrared laser energy on keratocytes, it presents days to weeks after treatment as severe photophobia with good visual acuity and requires intensive topical steroid therapy.⁵
4. Diffuse lamellar keratitis (DLK)—is generally more common than with microkeratome-made flaps because of the high energy involved.⁶

PENETRATING KERATOPLASTY

The utility of the laser lies in that it can fashion complex geometric patterns of trephination cuts. This produces greater wound stability, reduces the number of sutures and allows earlier suture removal.^{7,8}

Various geometric patterns, each with their own advantages, have been devised: the top-hat shape (replaces more of the endothelium, hence may be more useful in endothelial diseases), the mushroom shape (replaces more of the anterior surface, hence may be more useful in keratoconus), the tongue-groove configuration, etc.⁹

LAMELLAR KERATOPLASTY

Anterior lamellar keratoplasty is similar to LASIK flap creation except for the absence of a hinge and the lamellar cut being made at a deeper level. The laser is additionally used to prepare the donor corneal button (sans endothelium, Descemet's membrane and deep stromal layers) which is then placed on the host bed and secured with sutures.

Deep lamellar endothelial keratoplasty (DLEK) and Descemet's stripping automated endothelial keratoplasty (DSAEK): the trephination cuts are performed first, followed by the anterior lamellar interface cuts. Higher energy levels are required in oedematous corneas. The donor button is fashioned in a similar manner after mounting the corneoscleral button on an artificial anterior chamber.

Other uses in ophthalmology⁹, some of which are established and others being still under investigation, are:

1. to create pockets for intracorneal ring segments,¹⁰
2. laser-assisted astigmatic keratotomy,
3. obtaining corneal tissue for biopsy,¹¹
4. extracting corneal lenticles for correction of myopia,
5. non-penetrating glaucoma surgery,
6. creating intrastromal pockets for riboflavin instillation in eyes with keratoconus and
7. anterior capsulorrhexis in cataract surgery.

The femtosecond laser is also finding applications in dentistry and neurosurgery. It is making an impact as a 'nanoscalpel' in cell and tissue studies.¹²

CONCLUSION

Technological advances are enabling the femtosecond laser to continuously expand its versatility, safety, speed

and efficiency. An important limiting factor to its more widespread use remains its exorbitant cost.

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