Travel Medicine and Infectious Disease (2013) 11, 152–158

Available online at www.sciencedirect.com

SciVerse ScienceDirect

journal homepage: www.elsevierhealth.com/journals/tmid

REVIEW

Eye problems on expeditions☆

Daniel S. Morris [a,*], Sophie Mella [b], Diana Depla [c]

[a] Cardiff Eye Unit, University Hospital of Wales, Heath Park, Cardiff CF14 4XW, UK
[b] University of Cardiff Medical School, Cardiff, UK
[c] Ophthalmology Department, Cumberland Infirmary, Carlisle, UK

Received 18 July 2012; received in revised form 10 March 2013; accepted 13 March 2013
Available online 9 April 2013

KEYWORDS
Expedition ophthalmology;
High altitude retinopathy;
Refractive surgery

Summary *Background:* Visual loss in the wilderness setting is at best disabling and at worst potentially fatal. However many physicians have a poor knowledge of ophthalmology and the basic skills that could be applied in situations away from definitive care.
Method: This paper is intended for physicians, interested non-medical people and expedition operators as a practical guide to the treatment and prevention of eye problems on expeditions.
Results: Some of the eye conditions described in this paper are unique to the high altitude setting, such as high altitude retinopathy and some could happen in any environment, such as trauma, dry eyes and contact lens problems. As with any aspect of an expedition, preparation is vital to prevent and avoid eye problems. It is therefore important that pre-existing ocular conditions are known about and appropriate drugs and equipment are available in expedition first aid kits.
Conclusions: In the event of a visual problem, it is always better to be cautious and evacuate a patient rather than a risk a sight-threatening complication. However this paper should provide a non-ophthalmologist with the skills to treat the eye conditions described.

Introduction

Visual loss in the wilderness setting is potentially fatal. Firstly it may be a warning sign of a serious systemic problem and secondly the patient may lose their functional independence and ability to respond to objective danger.

The issues discussed in this paper fall broadly into two categories, those that are unique to the high altitude setting and those that could happen anywhere but require treatment to protect vision when standard ophthalmological care is unavailable. The aims are to provide practical knowledge on how to manage simple eye problems and also

☆ This paper is a consensus statement of the Medical Commission of the Union Internationale des Associations d'Alpinisme (UIAA MedCom) and was approved by written consent in lieu of a meeting on November 30th 2010.[d]

* Corresponding author. Tel.: +44 02920 742083; fax: +44 02920 748240.
E-mail address: dsm@doctors.org.uk (D.S. Morris).

[d] Members of UIAA MedCom are listed in Appendix section.

1477-8939/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.tmaid.2013.03.009

how to recognise the warning signs when evacuation may be required.

In keeping with all wilderness medicine, preparation and prevention are essential to avoid eye problems in the mountains. This paper is intended for physicians, interested non-medical people and expedition operators as a practical guide to the treatment and prevention of eye problems on expeditions.

Expedition preparation

The expedition doctor should be aware of any pre-existing ocular conditions or medical problems which may have ocular complications. With this in mind, the questions below should be built into the pre-expedition medical assessment (Table 1). A suggested ocular first aid kit is detailed in Table 2.

Pre-existing ocular conditions

The only ocular condition which excludes ascent to high altitude or even air travel is the immediate post-operative period following the use of intraocular gas in retinal surgery as this can expand and potentially cause a central retinal artery occlusion.[1] For more chronic eye diseases other precautions may need to be taken and regular medication should not be forgotten in the expedition environment.

Monocular vision

People with useful vision in only one eye should take extra care to protect their eyes from both the sun and objective dangers such as sand, ice and rock. It is therefore advisable to have specially designed polycarbonate safety glasses for any activities where flying debris could enter the eye.

Refractive errors

Refractive error can be corrected by spectacles, contact lenses, surgery or even a pinhole in a piece of cardboard. As a general rule, the best way to prevent problems is to use the same method of correction as you would at home and not try to suddenly change, for example, from spectacles to full time contact lens wear on an expedition. If you wear spectacles take a spare pair and get your prescription built into a pair of sunglasses or glacier goggles. Contact lenses and refractive surgery are discussed in further detail below (see Sections Contact lenses and dry eyes and High altitude and refractive surgery).

Cataract surgery

There are no special precautions required for people who have an intraocular lens following cataract surgery or clear lens extraction who want to ascend to high altitude. Although no formal studies have been performed to confirm this statement, there is plenty of anecdotal evidence from mountaineers, aviators and even astronauts.

Glaucoma

People on drops to reduce their intraocular pressure (IOP) should continue them as normal. There is no evidence to suggest that people with glaucoma cannot travel safely to high altitude, but a full eye check is recommended before travel. Acetazolamide (Diamox) used for the prophylaxis or treatment of acute mountain sickness in glaucoma patients could have a double effect as it significantly lowers IOP.

There is still debate as to the effect of high altitude on IOP, with some groups showing a decrease,[2,3] others have found increased IOP,[4,5] normal IOP[6,7] and even a reduction in IOP that occurred within hours of ascent and then recovered during acclimatization.[8,9]

Diabetes

There is no evidence that high altitude causes or exacerbates diabetic retinopathy.[10] Diabetic people also do not appear to be at any greater risk of high altitude retinopathy. However diabetics should maintain strict glycaemic control and acclimatise sensibly to avoid systemic or ocular consequences.

Advice should be sought before travel about the best method for glycaemic control depending on the anticipated activity together with how often blood sugar should be checked. Other people travelling with diabetics should be aware of the signs of hypoglycaemia and its treatment.

It would also be sensible to have a full eye examination approximately six months before going on any expedition so that if any treatment is required there would be time for the course of treatment to be completed.

Retinal surgery

There is some evidence that retinal detachment may be induced at high altitude[11] in susceptible individuals but once a detachment has been repaired successfully, there should be no risk at altitude. However if a person has recently had retinal surgery with intra-ocular gas they should not go into any environment where atmospheric

Table 1 Pre-expedition ocular screening questionnaire.

1. Do you wear contact lenses? — If yes what type are they? (e.g. hard/soft, monthlies/dailies)
2. Have you ever been treated by a doctor for an eye problem?
3. Have you ever had laser eye surgery or any other operation on your eyes? — If yes what type and when?
4. Does anyone in your family suffer from glaucoma or any eye disease?
5. Are you diabetic?
6. Do you have high blood pressure or heart problems?

Table 2 Expedition ocular first aid kit. The first aid kit listed below is lightweight and should fit into a small pouch. As an expedition doctor you should have some experience of using a loupe and ophthalmoscope as well as administering eye drops and applying a double eye pad.

Equipment
- Pentorch ± blue filter
- Pocket ophthalmoscope
- Magnifying loupe
- Eye pads (4)
- Eye shield
- Surgical tape
- pH paper
- Sterile surgical scissors
- Sterile surgical forceps
- Syringe, needle and local anaesthesia

Drops

Single dose (Minims™):
- Oxybuprocaine (topical anaesthetic)
- Fluorescein 1% (stain to identify abrasion or foreign bodies)
- Cyclopentolate 1% (pupil dilation and pain relief)
- Artificial tears (dry eyes and snow blindness)

Others:
- Antibiotic ointment e.g. Chloramphenicol
- Ofloxacin (any corneal or contact lens-related infection)
- FML (mild steroid, use cautiously)

Remember oral analgesia as required for a painful eye.

pressure is changed: this includes air travel and high altitude. People should not travel by air until the intra-ocular gas has been absorbed; this can be up to a month. Silicone oil in the eye or retinal buckle surgery are not contra-indications to air travel. People who have had recent retinal surgery should consult their ophthalmologist for advice on travel.

Snow blindness

Snow blindness is caused by unprotected exposure of the cornea and conjunctiva to ultraviolet (UV) light, specifically UV-B.[12] Snow blindness is therefore sunburn of the eye and can be extremely painful. Like sunburn, there is a delay between UV exposure and the onset of symptoms so by the time that the patient realises that they have snow blindness, the damage has already been done. Lay people should be advised to remember that the symptoms of snow blindness may develop even at night in the tent or hut when there was a high exposure earlier in the day.

Snow blindness is characterised by red, painful, gritty eyes with photophobia (aversion to light): many patients find it impossible to keep their eyes open. The conjunctiva will be red where it has been exposed to light and the cornea will show punctate staining with fluorescein drops.

Treatment of snow blindness includes local cooling (e.g. with cool, damp compresses), regular lubricating drops (artificial tears), antibiotic ointment (e.g. Oc. Chloramphenicol tds), rest and light avoidance. Recovery is usually within 24 h but beware of secondary infection as snow blindness renders the eye vulnerable.

Local anaesthetic eye drops should be avoided as these slow corneal re-epithelisation and therefore prevent healing whilst increasing the risk of infection. Such drops should only be used to allow examination and confirm no other causative pathology and to allow emergency evacuation from a perilous position if necessary. A greasy eye dressing with double padding can aid comfort for the first night and non-steroidal anti-inflammatory drugs make good oral analgesics to treat ocular pain. If the eyes are left unpadded but numbed from the examination make sure the patient does not sit unblinking as this will exacerbate the condition.

Avoidance of snow blindness is simply with sunglasses blocking all UV transmission, preferably of good quality (CE/EN protection class 3 or 4 and 100% UV protection) with protective sidepieces, or with goggles. These should be worn at all times in snow, especially at high altitude. In emergency, sunglasses can be made from a piece of bark or cardboard with small slits in it tied around the head. Porters are just as vulnerable to snow blindness, so don't forget to give them sunglasses too. The authors applaud initiatives by porter welfare organisations who are encouraging expedition leaders to provide their porters with eye protection.

High altitude retinopathy

High altitude retinopathy (HAR) is a pathological response by the retina to the hypoxia of altitude and it was first described in 1969.[13] Flame shaped haemorrhages and vascular tortuosity are most commonly seen but optic disc swelling, cotton wool spots, dot and blot, pre-retinal and vitreous haemorrhages have also been reported (Fig. 1).

Although HAR is usually asymptomatic, when a haemorrhage occurs over the macula, vision can be affected.

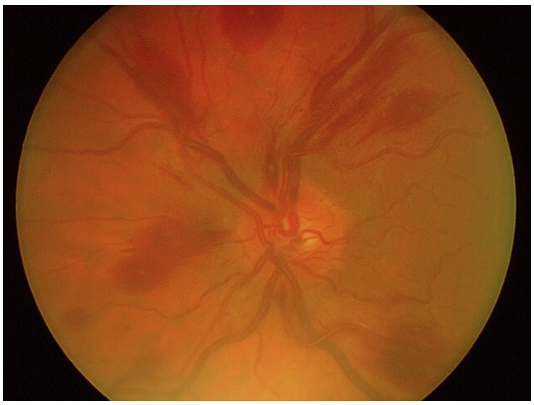

Figure 1 High altitude retinopathy at 5400 m. There was no change in vision but widespread haemorrhages and mild optic disc swelling. The patient also had severe AMS and descended 500 m for 3 days before making an uneventful ascent to 7400 m.

Previous studies have shown an incidence of HAR from 3.8% to 90.5% with an equal preponderance in males and females.[6,14] However it appears that about one quarter of people ascending to moderate altitude in the Himalayas are affected by asymptomatic HAR. The pathophysiology of HAR is unknown but highest altitude attained, rate of ascent and exertion appear to be risk factors.[15]

There is only anecdotal evidence to suggest a relationship between HAR, acute mountain sickness (AMS), high altitude cerebral oedema (HACE) and high altitude pulmonary oedema (HAPE). However retinal vascular dysregulation could herald similar problems in other organs and should not be taken lightly. A classification of HAR has been previously suggested by Wiedman and Tabin.[14]

Patients with decreased vision should descend immediately for further investigation and treatment as it is difficult in the field setting to diagnose and monitor HAR, especially for a non-ophthalmologist. Any concurrent AMS, HACE or HAPE should be treated aggressively to prevent potentially fatal sequelae. As with any altitude illness, each case should be managed individually in the context of any systemic signs and the ease of evacuation should it be required.

Acetazolamide (Diamox) is used for both the prophylaxis (125—250 mg bd from 1 day prior to ascent) and treatment (250 mg tds) of AMS. It is discontinued upon descent and side effects are common, such as nausea, vomiting, taste disturbance, paraesthesia and irritability. It is also known to reduce intraocular pressure and is used in the treatment of angle closure glaucoma. There is no evidence to suggest that it alters the incidence or natural history of HAR.

Loss of vision

Loss of vision should be of great concern to the expedition doctor. It is important to confirm if the patient has had any previous eye problems and then illicit whether one or both eyes are involved, whether the eyes are painful and whether the onset was acute. A full examination should be performed including visual acuity and pupil reactions in both eyes. If a cause can be found it should be treated but this should not delay evacuation for ophthalmological intervention.

Possible causes for painful loss of vision include acute angle closure glaucoma, uveitis, optic neuritis, orbital cellulitis, bacterial keratitis and snow blindness. The differential diagnosis of painless loss of vision includes retinal detachment, retinal artery or vein occlusion, cerebral ischaemia, HACE, HAR, ischaemic optic neuropathy, vitreous haemorrhage and malignant hypertension.

Contact lenses and dry eyes

Contact lens users are vulnerable to dry eyes and serious corneal infection in the expedition setting so they should be advised on sensible contact lens use (no more than 8 h a day), strict hygiene when handling lenses and to take plenty of spare lenses as well as spectacles to wear when they are not using their contact lenses.

Any potential infection, even what appears to be a simple conjunctivitis, should be taken very seriously. Contact lens wear should be stopped and then intensive broad spectrum antibiotic drops should be started (e.g. Ofloxacin hourly). If there is no improvement within 5 days, or the infection is getting worse with increased pain and decreased vision, the patient should be evacuated.

There is no evidence to suggest that contact lenses should not be worn at high altitude[16] but remember that they reduce oxygen delivery to the cornea which can lead to corneal oedema and therefore blurred vision even at sea level; at altitude there will be less available oxygen. Of preference the authors would recommend the use of daily disposable soft contact lenses over other types as they have a high water content, allow a high transmission of oxygen to the cornea and require less handling with no cleaning, making infection less likely.

Dry eyes are more common in the dry, windy, bright conditions found at high altitude or in polar regions.[17] Although often just a nuisance, severely dry eyes are very painful, can significantly blur vision and leave the eyes vulnerable to infection.

The main symptoms of dry eyes are red, painful, gritty eyes and any ocular lubricants can be used as treatment. Bear in mind that the more viscous ointments provide a longer period of relief but blur vision even further so are best reserved for use at night. Contact lens wear should be minimised in patients with symptomatic dry eyes and remember that goggles or wrap-around sunglasses can decrease evaporation of tears from the eyes and therefore decrease symptoms.

High altitude and refractive surgery

Refractive surgery is popular with active people who enjoy sports and outdoor recreation so that they can avoid the use of spectacles and contact lenses. However altitude can transiently affect the visual outcome which could be life-threatening. This was famously demonstrated by Dr Beck Weathers attempting to climb Mount Everest in 1996 after he had radial keratotomy (RK).[18]

A general trend towards long-sightedness has been found in subjects at altitude who have had RK (where deep radial cuts are made in the cornea).[19] This appears to be related to swelling of the corneal stromal fibres on either side of the keratotomy incisions as a result of the low atmospheric oxygen, causing the weakened cornea to expand circumferentially, making the eye longsighted. One possible answer would be to take spare "reading glasses" of +1.00, +2.00 or +3.00 to use as distance glasses under glacier goggles when necessary.

Radial keratotomy has now been superseded by excimer laser keratectomy where a laser is used to shave off part of the cornea to alter the refractive power. This can be done either after removing the corneal epithelium (PRK), making a flap out of the corneal epithelium which is then replaced (LASEK) or creating a flap which include corneal epithelium and anterior corneal stroma (LASIK). These newer techniques cause less change at high altitude but can still cause a shift towards short-sightedness, first reported in 2000 when a climber who had received LASIK experienced blurred vision at 19,500 feet which cleared on descent.[20]

There is also an element of individual susceptibility as many people who have had refractive surgery experience no problems whatsoever at altitude. However patients should be advised not to have refractive surgery within 3 months of an expedition as refraction can be unstable and the eye is at risk of infection. Any infection or decreased vision in a patient who has had refractive surgery should be taken seriously and descent should be considered.

Trauma

Corneal abrasion

A corneal abrasion is a tear in the corneal epithelium usually through mild trauma, such as removing a contact lens or perhaps even whilst asleep. It is exquisitely painful and topical anaesthetic drops will provide immediate relief, but should not be used as a treatment because topical anaesthetic drops delay corneal epithelial healing and prevent the patient from knowing whether they are touching their cornea or if their condition is getting worse through increased pain. Fluorescein will confirm the diagnosis and treatment is with antibiotic drops or ointment. An eye pad is not usually necessary and can encourage infection.

Corneal foreign body

Occasionally the protective blink reflex fails and allows a foreign body to embed itself into the cornea. This can be metallic or organic and a metallic foreign body will often leave a rust ring. The mechanism of injury should be ascertained as a high velocity foreign body is more likely to penetrate the globe (such as a shard of metal from an ice-axe.)

A corneal foreign body will cause a red, painful gritty eye and the sensation that something is in the eye. The foreign body is usually very small but fluorescein and a magnifying loupe can assist identification and removal, either with a cotton bud or a 25G needle. Patients should then be given antibiotic ointment (e.g. Chloramphenicol ointment tds). Eversion of the upper eyelid should be performed to exclude a sub-tarsal foreign body.

Chemical injury

A chemical splash can be sight-threatening so immediately irrigate profusely, preferably with sterile normal saline. Check the pH with litmus paper if available and continue irrigation until pH is 7. Any liquid can be used for irrigation (with the possible exception of milk) and irrigation may need to be performed for many hours to remove the offending chemical. Irrigation can be painful but it is important to persist; topical anaesthesia may help the patient tolerate the procedure. It is important to identify the chemical as alkali penetrates the ocular tissues much faster than acid and therefore has a worse prognosis. Treatment should include antibiotic ointment (e.g. Chloramphenicol tds), lubrication (e.g. artificial tears hourly) and cycloplegic drops (e.g. cyclopentolate tds) for pain relief. Note that a white eye in the acute phase could indicate severe ischaemia. Chemical eye injuries are sight-threatening and the patient should be evacuated for specialist treatment.

Eyelid laceration

The eyelids play an important role in protecting the eye and preventing corneal desiccation. If they are damaged, the eye can be rendered vulnerable. The underlying eye should always be checked for a penetrating injury to the globe, especially if the mechanism of injury was high velocity. The wound should be examined carefully and cleaned if necessary. If the lid margin is interrupted and the ends are not opposed, primary repair under local anaesthesia should be considered. This is especially important with the upper lid to prevent corneal exposure. If repair is not possible, apply plenty of antibiotic ointment (e.g. Chloramphenicol tds) and patch the eye if you are concerned about exposure before arranging evacuation.

Penetrating eye injury

A penetrating eye injury involves disruption of the globe integrity and is a serious, sight-threatening problem. In the wilderness setting a penetrating injury may be sustained from hammering a metal peg, a chip of rock, a tree branch, a walking pole or even a fishing hook. The mechanism of injury is important in determining whether there could be an intraocular foreign body or a perforating injury (entry and exit). A high suspicion of penetrating injury should be maintained in any high velocity high injury, such as those involving firearms, explosions or hammering. Signs to be looking for include decreased vision, a soft watery eye (gently compare the pressure of both eyes with your thumbs), a peaked pupil (i.e. not round) and expulsion of ocular contents.

Any suspected penetrating eye injury should be immediately evacuated for specialist treatment. Broad-spectrum systemic antibiotics should be started and any expulsed ocular contents should not be touched; antibiotic ointment and a pad should be applied to the eye.

Blow-out fracture and blunt trauma

Blunt trauma to the globe (for example from a fall or a punch) can cause the bony orbital floor to fracture tethering the inferior rectus muscle and limiting upgaze. This causes double vision, a sunken eye and pain on eye movement. The double vision may be intolerable in which case the damaged eye should be patched. Remember that blunt trauma can cause many other problems within the eye, such as hyphema, subluxed lens, vitreous haemorrhage, retinal detachment and globe rupture. If visual acuity is decreased, consider evacuation for specialist evaluation.

Orbital compartment syndrome

The orbit is a relatively closed compartment with limited ability to expand, so orbital pressure can rise rapidly when an acute rise in orbital volume occurs. This is an emergency where prompt simple treatment can prevent blindness.

The most common cause of orbital compartment syndrome is retro-bulbar haemorrhage from trauma, especially in the wilderness setting, but spontaneous retro-bulbar haemorrhage can also occur due to venous anomalies, intra-orbital aneurysms and malignant hypertension. Severe orbital cellulitis with an abscess can also cause an orbital compartment syndrome. Patients with increased orbital pressure present with pain causing vomiting, proptosis, red and swollen conjunctiva, limited eye movements and decreased optic nerve function (decreased vision and an afferent pupillary defect).

Treatment is with a surgical lateral canthotomy and cantholysis to release the pressure. This is a relatively straightforward procedure that can be performed as an emergency procedure under local anaesthesia if evacuation is not possible. The lower eyelid is completely detached from the lateral orbital rim using scissors, first horizontally to cut through the lateral canthal angle (canthotomy) and then vertically to cut the lateral canthal tendon (cantholysis). If the lid is held with forceps it is possible to feel when the tendon has been severed. The patient should then be evacuated for specialist evaluation and treatment.

Conclusion

Ophthalmology is viewed by the general physician with anything from mild boredom to abject fear. Unfortunately these fears may have to be faced in the wilderness setting and this paper is designed to equip people with the tools required to assess and treat an eye problem in the wilderness setting. Visual acuity is the single most important sign when examining the eye and a chart is not necessarily required. Simply ask the patient if their vision has changed, compare the two eyes by covering one then the other or use an old magazine. Acute eye problems are often very painful, so it is important to remember the role of systemic analgesia in treatment. Preparation is vital to prevent eye problems on expeditions, especially ensuring that everyone including porters have adequate eye protection. In the event of a visual problem, it is always better to be cautious and evacuate a patient rather than a risk a sight-threatening complication.

Authorship

All authors have made substantial contributions to either the conception and design of the study, or acquisition of data, or analysis and interpretation of data, drafting the article or revising it critically for important intellectual content and final approval of the version to be submitted.

Conflict of interest

The authors confirm that this work was unfunded and they have no financial or personal relationship with other people or organisations that could inappropriately influence their work.

Appendix A. Members of UIAA MedCom (in alphabetical order)

C. Angelini (Italy), B. Basnyat (Nepal), J. Bogg (Sweden), A.R. Chiocconi (Argentina), N. Dikic (Serbia), W. Domej (Austria), P. Dobbelaar (Netherlands), E. Donegani (Italy), S. Ferrandis (Spain), U. Gieseler (Germany), U. Hefti (Switzerland), D. Hillebrandt (U.K.), J. Holmgren (Sweden), M. Horii (Japan), D. Jean (France), A. Koukoutsi (Greece), A. Kokrin (Russia), J. Kubalova (Czech Republic), T. Kuepper (Germany), J. McCall (Canada), H. Meijer (Netherlands), J. Milledge (U.K.), A. Morrison (U.K.), H. Mosaedian (Iran), R. Naeije (Belgium), M. Nakashima (Japan), S. Omori (Japan), P. Peters (Luxembourg), I. Rotman (Czech Republic), V. Schoeffl (Germany), J. Shahbazi (Iran), J.C. Skaiaa (Norway), J. Venables (New Zealand), J. Windsor (U.K.).

References

1. Polk JD, Rugaber C, Kohn G, Arenstein R, Fallon Jr WF. Central retinal artery occlusion by proxy: a cause for sudden blindness in an airline passenger. *Aviat Space Environ Med* 2002;**73**(4): 385—7.
2. Somner JEA, Morris DS, Scott KM, McCormick IJC, Aspinall P, Dhillon B. What happens to intraocular pressure at high altitude? *Invest Ophthalmol Vis Sci* 2007;**48**(4):1622—6.
3. Brinchmann-Hansen O, Myhre K. Vascular response of retinal arteries and veins to acute hypoxia of 8,000, 10,000, 12,500, and 15,000 feet of simulated altitude. *Aviat Space Environ Med* 1990;**61**(2):112—6.
4. Ersanli D, Yildiz S, Sonmez M, Akin A, Sen A, Uzun G. Intraocular pressure at a simulated altitude of 9000 m with and without 100% oxygen. *Aviat Space Environ Med* 2006;**77**(7): 704—6.
5. Carapancea M. Experimental and clinical hyperophthalmotony of high altitudes. *Arch Ophthalmol Rev Gen Ophthalmol* 1977; **37**:775—84.
6. Clarke C, Duff J. Mountain sickness, retinal haemorrhages and acclimatisation on Mount Everest in 1975. *Br Med J* 1976;**ii**: 495—7.
7. Bayer A, Yumusak E, Sahin OF. Intraocular pressure measured at ground level and 10,000 feet. *Aviat Space Environ Med* 2004; **75**:543—5.
8. Cymerman A, Rock PB, Muza SR, Lyons TP, Fulco CS, Mazzeo RS, et al. Intraocular pressure and acclimatization to 4300 M altitude. *Aviat Space Environ Med* 2000;**71**(10):1045—50.

9. Pavlidis M, Stupp T, Georgalas I, Georgiadou E, Moschos M, Thanos S. Intraocular pressure changes during high-altitude acclimatization. *Graefes Arch Clin Exp Ophthalmol* 2006; **244**(3):298—304.
10. Leal C, Admetlla J, Viscor G, Ricart A. Diabetic retinopathy at high altitude. *High Alt Med Biol* 2008;**9**(1):24—7.
11. Morris DS, Severn PS, Smith J, Somner JEA, Stannard KP, Cottrell DG. High altitude and retinal detachment. *High Alt Med Biol* 2007;**8**(4):337—9.
12. Hietanen M. Ocular exposure to solar ultraviolet and visible radiation at high latitudes. *Scand J Work Environ Health* 1991; **17**:398—403.
13. Singh I, Khanna PK, Srivastava MC, Lal M, Roy SB, Subramanyam CS. Acute mountain sickness. *N Engl J Med* 1969; **280**(4):175—84.
14. Wiedman M, Tabin GC. High altitude retinopathy and altitude illness. *Ophthalmology* 1999;**106**:1924—7.
15. Morris DS, Somner J, Donald MJ, McCormick IJ, Bourne RR, Huang SS, et al. The eye at altitude. *Adv Exp Med Biol* 2006; **588**:249—70.
16. Flynn WJ, Miller 2nd RE, Tredici TJ, Block MG. Soft contact lens wear at altitude: effects of hypoxia. *Aviat Space Environ Med* 1988;**59**(1):44—8.
17. Gupta N, Prasad I, Himashree G, D'Souza P. Prevalence of dry eye at high altitude: a case controlled comparative study. *High Alt Med Biol* 2008;**9**(4):327—34.
18. Krakauer J. *Into thin air: a personal account of the Mount Everest disaster*. London: Random House; 1998.
19. Mader TH, White LJ. Refractive changes at extreme altitude after RK. *Am J Ophthalmol* 1995;**119**:733—7.
20. White LJ, Mader TH. Refractive changes at high altitude after LASIK. *Ophthalmology* 2000;**107**(12):2118.

Further reading

1. Mader TH, Tabin G. Going to high altitude with pre-existing ocular conditions. *High Alt Med Biol* 2003;**4**(4):419—30. Winter.
2. Ellerton JA, Zuljan I, Agazzi G, Boyd JJ. Eye problems in mountain and remote areas: prevention and onsite treatment — official recommendations of the International Commission for Mountain Emergency Medicine ICAR MEDCOM. *Wilderness Environ Med* 2009;**20**(2):169—75. Summer.
3. Johnson C, Anderson SR, Dallimore J, Winser S, Warrell DA. *Oxford handbook of expedition and wilderness medicine*. Oxford: Oxford University Press; 2008.