properly applied, then we will hear less of such trouble as detachment of the retina.

In my method we put pressure on the lower third of the lens through the cornea and continue that pressure throughout at right angles to the anterior surface of the lens as it emerges. This causes the lens to swing round on its transverse axis. The suspensory ligament is thus ruptured first opposite the middle of the wound. The Barraquer instrument should grip the front of the lens and then be rolled between the fingers so as to do exactly the same thing. As used by some operators when it gets its grip it is made simply to lift forward the lens. By this means a temporary vacuum is produced behind the lens which *ipso facto* lifts forward the vitreous body, and hence dislocation of the retina or even of the choroid. When, however, it is made to roll on its transverse axis so as to rupture the suspensory ligament at the wound first, then air passes behind the lens and no such vacuum lifting the whole contents of the eye forward comes into action. This is the essential point to keep in mind when using this instrument. As to the range of adaptability of this instrument, it is not suitable for Morgagnian cataracts or cataracts with an easily ruptured capsule. On the other hand, such cases are as easily extracted by my method as any other class.

BILATERAL CHANGES IN THE CORNEAE FOLLOWING EXPOSURE TO COLD IN AN AIRMAN*

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THE lesion here described occurred in exceptional circumstances and is of considerable interest as it is probably unique in ocular pathology.

An airman officer, V. V., of Messina, 23 years of age, started for an aerial expedition from a mountainous zone in April, 1917. After about an hour of flight he lost the left glass of his protecting spectacles, and two hours later lost the other glass as well. The aeroplane reached and maintained the height of 4,500 metres over mountainous country which was covered with snow. The airman stated that as soon as the left eye was exposed he felt a strong sensation of cold accompanied by lacrimation which, however, only lasted a short time. He had considerable difficulty in keeping the eyes open at first, but later could do so easily. The lacrimation

* From *Pathologica*, N 155.

had then ceased and the sensation was one of dryness with gradually diminishing visual acuity. This latter was so reduced that, on descending at the close of his expedition, he was unable to find his proper starting point, to which he should have returned, and was unable to distinguish any object with the right eye, and only with considerable difficulty with the left.

Examination, twenty minutes after his descent, gave the following result :—

Right eye. The cornea showed diffuse opacity like ground glass, most marked in the centre. The opacity was situated in the superficial layers of the cornea, the epithelium of which was slightly swollen in the centre and loosened, as in some eyes after the use of cocain. The iris could be made out and seemed normal in appearance and reaction. The corneal sensibility was not altered. There was some bulbar and pericorneal injection. Vision, 7/200.

Left eye. Condition similar to the right, but without the loosening of the corneal epithelium. Vision, 10/200.

The skin of the eyelids was normal, but there was frostbite of the first degree of the skin of the cheeks and nose.

On the following day there was still some alteration in the corneae; the corneal epithelium of the right eye was restored. Three days later both corneae were normal and full visual acuity had been regained.

Remarks

The lowest temperature to which the airman was exposed during his flight must have been about -25° C. This has been deduced both from questioning airmen and from the results published by Professor Gamba of the Aerological Observatory of Pavia.⁽¹⁾ This observer found with balloons that at the height of 4500—5000 metres the temperature was between 23.9° and 28.9° C.; the lowest temperatures being found in April, since the seasonal variation of temperature is later at a great height than on the earth's surface. Gamba's observations are in close agreement with those made by Teyserluc de Bert (Observatory of Trappes); H. G. van de Sande, Backhuyze (Tegel); Schmaus of Munich and de Marchi, for heights above 1,000 metres, so that the temperatures of the upper air do not seem to be much affected by differences in the geographical situation.

In the case here described owing to the flight being over snow-covered mountains the temperature must have been particularly low. An additional factor in producing the ocular lesions is to be found in the rapid movement of the air causing irradiation of surface heat and tending to lower it to that of the surrounding atmosphere, namely, about -25° C. Although evidence of the

admirable protection of the eye from traumatism from blows and foreign bodies is constantly brought to our notice, the same cannot be said of the mechanism of defence against extreme variations of the external temperature. From this point of view the thermo-regulating mechanism of the cornea is of chief importance, both because it is the most exposed part of the eye and also because, in the absence of blood vessels, it does not possess the protection afforded to other parts of the body by the circulation. The corneal temperature is maintained by irradiation from the neighbouring tissues, principally from the aqueous, the temperature of which is maintained by the rich plexus of vessels in the iris and ciliary body. v. Michel⁽²⁾ has shown that the temperature of the aqueous is 7° lower than the rest of the body, while that of the cornea is 0.10° lower still. Hertel⁽³⁾ has shown that applications of cold or hot compresses to the closed eyelids cause considerable variations in the corneal temperature; it is, therefore, reasonable to assume that perceptible variations must also occur in agreement with other external conditions. A complete corneal circulation has been discussed by Leber⁽⁴⁾ and others and rejected, but even if it could be proved to exist it would be unable to neutralize the effects of marked variations in the external temperature. The lids with their dense vascular network, placed like a screen, play a notable part in the defence of the cornea, a defence that is perfect during sleep, and by no means negligible during the waking period, as it has been shown by v. Michel experimentally that forcible keeping open of the palpebral fissure lowers the temperature of the anterior segment of the eye and the aqueous. Winking increases when the need of defence arises and the palpebral opening may be kept half closed or even completely shut. The lacrimal secretion, the orbital arches and the nose also aid the defence against cold.

I have not been able to find any description of similar lesions to that described above as the result of exposure to cold. Kurizin⁽⁵⁾ records a case of a man lost in the open country in Russia, owing to a sudden snowstorm, in whom exposure for a whole day resulted in frostbite of left foot and of nose and bilateral corneal ulceration. The ulcers penetrated down to Descemet's membrane and were symmetrically situated in the palpebral aperture. There was very little inflammatory reaction and they healed in about three weeks. The author thinks that they were really due to partial necrosis of the cornea from cold, an opinion supported by their symmetry, situation and clinical history. Kurizin's case differs from the one described above in the length of exposure and the impossibility of excluding traumatism from fragments of ice, etc., that may have been blown into the eye by the heavy storm. Dubois de Lavigerie⁽⁶⁾ also records a case of bilateral lesions of the cornea which occurred in a cyclist during a winter race with

aviators. The lesions took the form of opacity without any superficial change, and were first noted after fifteen hours. Twenty-four hours later the corneae had completely recovered. In this case also mechanical causes cannot be excluded.

I consider that the sequel of events in my case can best be explained as follows:—As soon as the left glass was lost and while the airman was still at a comparatively low altitude, he must have felt the cold severely in that eye, but, by continual winking the freezing effect must have been considerably neutralized. Since the airman had an absolute and pressing necessity to see in order not to lose his way, his efforts, especially after the loss of the right glass, must have been constantly directed to keeping the palpebral fissures open. As the aeroplane rose the temperature fell and the analgesic action of the cold on the corneae made itself felt. Although we have no clinical evidence of any analgesic action of cold on the cornea we know that complete surgical anaesthesia can be obtained by freezing in other parts of the body, and we can assume that the same effect would follow in the cornea. As the corneae became insensitive the airman would have no difficulty in keeping his eyes open, thus depriving them of the normal protective mechanism. Other causes may also have contributed in producing the lesions found, such as the air resistance and the drying of the external surface of the eye from the rapid current of air caused by the aeroplane's flight. Under ordinary circumstances the necessity for increase of the lacrimal secretion can be readily met, so that, at first, increased secretion would take place which by its evaporation would aid the lowering of the corneal temperature. Later, the insensibility of the cornea would lessen the demand on the lacrimal secretion and the cornea would be insufficiently moistened, as was noticed by the airman, who said he experienced a sensation of dryness of the conjunctiva. What liquid did reach the surface of the eye must have rapidly evaporated owing to the rate of movement through the air. Further, the extreme cold also affected the vascular supply of the face and lacrimal glands. I also consider that the friction of the air resistance at the rapid rate of movement may have added some traumatic effect.

It is interesting now to conjecture what may have been the histological changes in the cornea that produced the observed changes. The fact that the transparency of the ocular structures is easily altered by cold had been previously noted. Thus in 1857 Kunde⁽⁷⁾ observed changes in the lens of certain animals (frogs, pigs, etc.); similar observations were also made by Daddi,⁽⁸⁾ Abelsdorf⁽⁹⁾ and v. Michel.⁽¹⁰⁾ v. Michel's observations showed that in living animals (cats, calves and others), and in enucleated human eyes the cornea and lens became opaque under the influence

of cold, while the aqueous and vitreous remained transparent, even when completely frozen. Haziness of the cornea begins to appear at 7°C ., that of the lens at 6°C ., increasing as the temperature falls, so that at -4°C . the cornea becomes like porcelain. As the temperature again rises the transparency is slowly regained, and is again lost if the temperature falls. In his experiments the transparency was normal twenty-four hours after the freezing. To understand the mechanism of this loss of transparency it is necessary to consider the chemical constitution of the cornea and lens. Both structures, although containing much water (76.6% to 76.9% in the case of the cornea, His, Leber), also contain a fair amount of albumin. The watery component is largely combined with the other chemical constituents of the cornea, as only one fifth can be extracted by evaporation methods. The other constituents consist in albumins and globulins (about one quarter of the total weight), and rather less than 1% of inorganic salts. The lens contains a rather higher percentage of organic material, nearly one-third by weight. The aqueous and vitreous are much richer in water and do not contain more than 1% of organic material. It is this chemical constitution that accounts for the loss of transparency in the cornea and lens, while the aqueous and vitreous are unaffected. According to v. Michel separation of the water takes place in the tissues that are richer in albumin, producing an alteration in the refractive condition without any modification of the anatomical structure. The conditions under which the airman was placed were similar to those of the experiments; it is, therefore, reasonable to assume that similar changes took place, especially when we consider that haziness of the cornea in animals begins at a temperature of 7°C .

As I have stated above, it is my opinion that the temperature of the airman's cornea, considering the diminished winking, was probably below 7°C ., so that the alteration of transparency must have been partly produced by the chemico-physical change which involved, as in the animal experiments, the separation of the watery constituent and an alteration in refraction effect. But in my case definite anatomical changes also occurred in the corneal epithelium and parenchyma. These changes, particularly the desquamation of the corneal epithelium, I attribute to dryness owing to the insensibility and diminished lacrimal secretion. I feel assured that definite infiltration of the tissues took place since the opacity lasted 48 hours as opposed to the twenty-four hours found in animal experiments; all the more so when the length of time, three hours, during which the eye was exposed to the injury, and the readiness with which infiltration between the corneal lamellae and epithelium takes place are considered. I do not suppose it possible that appreciable anatomical alterations

could have taken place in the corneal lamellae on account of the relatively rapid and complete return to normal.

Summary

An airman exposed to direct action of cold and air resistance during a three hours' flight, suffered from bilateral corneal lesions characterised by ground glass opacity, most marked in the centre, and by epithelial desquamation. I consider that the lesions were caused by dryness and partly by separation, and possibly freezing, of the watery constituent of the corneae; partly, also by interlamellar infiltration with degeneration and desquamation of the superficial layers of the epithelium. The intense cold (about -25°C.) produced insensibility of the corneal surface which had lost its protection, and, also, of the anterior part of the eyeball, and thus facilitated the production of the lesions by allowing the airman to keep his eyes open without pain while diminishing the lacrimal secretion.

REFERENCES

1. Gamba.—"Risultati di lanci di balloni sonda e piloti." *Annali R. Uff. di Meteorologia, ecc.* Vol. XXXV, 1913; see also Vol. XXX, 1908.
2. Michel.—"Die Temperature Topographie des Auges." *Arch. f. Ophthal.*, Vol. XXXII, Part i, 1886.
3. Hertel.—"U. Wirkung v. kalten u. warmen Umschlagen, etc.," *ibid.*, Vol. XLIX, Part ii, 1900.
4. Leber.—Graefe-Saemisch "Handbuch f. g. Augenheilk." (2nd edition.)
5. Kurizin.—"Ein Fall v. part Nekrox, etc." *Jahresbericht f. Ophthal.*, 1888.
6. Dubois de Lavigerie.—"Accidents oculaires chez un bicycliste." *Ann. d'Ocul.*, Vol. CLXIII, 1895.
7. Kunde.—"Notiz ueber den Einfluss des Kalte auf die Linse." *Arch. f. Ophthal.*, Vol. III, Part ii, 1857.
8. Daddi.—"Oszervaz sulla cataratta, ecc." *Annali d'Ottalmologia*, 1898.
9. Abelsdorf.—"Zur un Augensimptom, etc." *Centralbl. f. Physiologie Festschrift* 1899. N. 4.
10. v. Michel.—"U. d. Einfluss d. Kaltes auf die brechende Medien d. Auges." *Beitr. z. Physiologie, Festschrift für Fick*, 1899.

ANNOTATIONS

Improvement of Visibility

It has long been known that much of the light reflected from a mirror is polarised, and it has been found in practice that the interposition of a Nicol's prism in viewing objects under water very materially improves visibility. During the war the Admiralty utilised this phenomenon in devising means to penetrate fog, for