The Eye – A Sanctuary from Thermal Injury

The J Fred Leditschke Tribute Paper

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An ANZBA Tribute

The domain of preventive medicine underpins all the specialties involved in the management of thermal injury. Throughout the past five decades, one of the leaders in the prevention of trauma in Australia has been Professor John Frederick Leditschke, known universally and with great affection as “Fred”. Professor Fred Leditschke has been an uncompromising advocate, indeed a leader, in each of the four domains of injury prevention – the three primary domains of education and the public awareness of risk; of the better and safer design of products which might otherwise cause injury; and the promotion of legislation to guarantee a safer environment for the innocent and vulnerable, particularly children.

In addition to his leadership role in these three arms of primary injury prevention and safety promotion, Professor Leditschke has been a leader also in the field of secondary prevention -- promoting more widespread bystander first aid and resuscitation skills, specifically in the pre-hospital domain.

Over many decades Fred has been a fearless advocate for the public awareness of risk. He has promoted safer design, for example, in the installation of shatter-proof glass. He has been an advocate for legislation, particularly that involving flame-proof nightwear for toddlers. In the fourth domain of preventive medicine, that of secondary prevention, his service, initially as the National Chief Surgeon for St John Ambulance Australia (1990 – 1996), and subsequently as Chief Commissioner for St John Ambulance Australia (1999 – 2005), has been outstanding.

Professor Leditschke’ s role, in injury prevention and safety promotion, has been focussed not only on endeavours to reduce burns and scalds; but also advocacy for the installation and use of seat belts, the wearing of bicycle helmets, and drowning prevention. Preventive medicine is the poor relation of healthcare; and in the domain of trauma and injury, this field has been chronically underfunded; and when funded, has been the first to have its resources cut, when seemingly inevitable budget purges ensue. Professor Leditschke has stood tall in each of these domains of preventive medicine; and has used the priceless resource of his own volunteer service to promote safety.

Professor Leditschke was a Founder of ANZBA, and contributed to its first meeting, held at Monash University. He was elected President of ANZBA in 1986, serving in that role from 1986 to 1988. He was also one of the early supporters of the Child Accident Prevention Foundation of Australia (CAPFA, now KIDSAFE), from 1979. He was elected the National President of CAPFA and served in this crucial role from 2002 to 2005. He has served with distinction for more than five decades as a general paediatric surgeon, with special skills and interests in urogenital surgery and in the management of burns. He was elected President of the Australasian Association of Paediatric Surgeons; and for more than two decades (1997 – 2018) has served as President of the Child Restraint and Safe Travel Subcommittee (CREST) of the Royal Australasian College of Surgeons.

The broader family of the Australian and New Zealand Burns Association, comprising as it does surgeons, nurses, paediatricians, occupational therapists, physiotherapists, speech pathologists, social workers, teachers, researchers, scientists and healthcare executives, join together to pay this public tribute to Professor Leditschke, now in his retirement.

Introduction

All who work in the field of thermal injury know that burns which involve the eyes are rare events.

In a recent survey of 1600 consecutive burns to children, undertaken at the Children's Hospital in Brisbane, some 700 involved burns also to the face. Only three involved damage to the eyes. In evolutionary terms, any individual, *Homo sapiens* included, died if they were blinded, and their genes could no longer be passed on.

The question arises, what are the mechanisms which protect the eyeball, and specifically the cornea and sclera, in the context of otherwise severe facial and periorbital burns?

Four mechanisms combine to protect the cornea and the globe behind it. These four defence mechanisms, wondrous in their complexity but pragmatic in their protective effects, have evolved to offer a powerful degree of protection, in the face of a thermal insult. They are the:

Blink Reflex,

Menace Response,

Bell's Phenomenon, and the

Barrier of Tears

Together, they combine to form a triple layer of physical protection—an inbuilt body armour—when a heat source targets the eye.

Blink Reflex

The blink reflex is a universal protective reflex, present in all mammals. It is elicited by any one or more afferent stimuli, including touching the cornea, the glabella reflex, and somatosensory stimuli including sudden sounds and light. The blink reflex is elicited by a blast of hot air, a flash, or the touch of particulate matter. The blink reflex is the fastest protective reflex in the body, with a response time of 0.1 of a second – exceeded only in response time by that of the vestibulo-ocular reflex (this latter, with a response time of 0.05 seconds).

The blink reflex has two components, designated as R1 and R2. The R1 reflex is a unilateral response with an average reaction time of 100 milliseconds, or 1/10 of a second. The R2 reflex quickly follows, as a bilateral blink, with lid closure with an average response time of 290 milliseconds. If a unilateral stimulus triggers a blink, it is obviously safer that both eyes be protected, in teleological terms. If a flash occurs, with resulting flying hot fragments or drops of scalding liquid, the eyes are protected by the blink response in the interval between the afferent incoming signal and the physical closure of the eyelids. During a blink, the eyeball also retracts.

The blink reflex is not modified by gender, but slows with age. Its integrity depends on higher functional input, including that from the basal ganglia. In some diseases which are characteristic of senior years, such as Parkinson's disease with dysfunction in the basal ganglia, the blink reflex is slowed.

Menace "Reflex"

Another powerful protective reflex is the Menace Response. This menace "reflex" involves the blinking and aversive turning of the head away from a rapidly approaching physical stimulus, whether this be a physical object, thermal stimulus or air movement. It is not strictly a reflex, in that

higher cortical function is necessary for the effector (motor) avoidance response. The neural path involves the optic nerve (CN II) transmitting the visual signal of threat, higher interpretive centres at the midbrain or thalamus levels or above, a segment of the (motor) corticospinal tract, and the effector nerves (CN VII and CN XI). These stimulate the innovated eyelid and neck muscles.

The average reaction time for the Menace Response, in healthy young adults, is 247.6 milliseconds. There is a small but significant gender effect (males 239.7 ms; females 255.5 ms); and a significant learning effect on the response times of the Menace Response to a visual threat., such as fire or hot fluid splashes.

Bell's Phenomenon

When we close our eyes, our eyeballs rotate upwards. We can't normally see this, because the eyelids are closed. Bell's Phenomenon, in neurological terms an Associated Movement, was first described by Dr Charles Bell in Oxford in 1823. It does not occur during the normal spontaneous blinking which lasts only a fraction of a second, but occurs as a consequence of conscious eyelid closure, and during sleep. It is another protective reflex, protecting the cornea from frontal injury, even when the eye is closed. It occurs in all mammals; and in humans, can be demonstrated in 97% of infants by four months of age. This phenomenon thus forms a two-layer protection of the cornea if the eyes are shut tightly--- that of the eyelid itself and the cornea rolled upwards under the bony roof of the orbit. The tighter the blink or voluntary eye closure, the greater the amplitude of the upward movement of the eyeball.

Tears

The thin layer of tears which lubricate and protect the exposed anterior parts of the eyeball provide further protection, a third bulwark, from thermal injury. Water has a low Coefficient of Thermal Conductivity – 0.00143 Calories per centimetre per second per degree Centigrade. (Comparative indices of this Coefficient are: silver 1.006; asbestos 0.0004; air 0.00005). The SI unit of the Coefficient of Thermal Conductivity is: Watts per metre per degree Kelvin.

Prevention Better Than Cure

These priceless protective reflexes see, in one sense, their parallel in the broader discipline of preventive medicine. In this Tribute Address, one acknowledges the signal role played by Professor J. Fred Leditschke in the domain of preventive medicine. One presents here some visual examples of Professor Leditschke's advocacy and service role, in creating a safer life for all. At this International Conference, and in his presence and that of his family, now in his retirement, we acknowledge his leadership and service; and the enrichment he has brought to the lives of the thousands of families who have known him as their doctor, and their "Fred".