CHAPTER 1

History of ophthalmic blocks

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Introduction

Most eye surgeons regard the term ophthalmic "blocks" as referring to the application of local anaesthetic agents around, above, and/or behind the eyeball to keep the eye pain-free during surgery. Additionally, most ophthalmic blocks aim to inhibit the movement of the extraocular muscles, ensuring the eye remains numb and immobile for the procedure. The history of ophthalmic blocks essentially started with the discovery of injectable local anaesthetic agents in 1884.

The advent of pain-free surgery in the 19th century dates to the general anaesthesia revolution in 1846 and the second, local anaesthesia, revolution of 1884. Surgeons could now take their time to operate on an immobile eye, having previously been obliged to perform a quick procedure on a patient and eye who was constantly moving because of the pain of surgery. This, in turn, enabled the development of more refined techniques, resulting in improved outcomes. The concurrent development of sterilisable needles and antisepsis techniques was necessary to make surgery in general, and eye surgery in particular, the success story it is today.

The main techniques of ophthalmic block are variants of the older/classical retrobulbar block (in which a sharp needle is aimed within the cone that is formed by the extra-ocular muscles) and peribulbar (needle aimed into the orbit but outside the cone or sub-Tenon's block (usually a blunt cannula, placing anaesthetic in the fascial plane between the sclera and surrounding Tenon's capsule). This chapter aims to highlight some of the important moments in the history of ophthalmic anaesthesia, especially those that continue to inspire our current practice of 'block' anaesthesia.

Earlier history

The history of surgery goes back to prehistoric times, with osteological evidence that at least some patients survived the operation of skull trepanation. While there is, of course, no such evidence of eye surgery in prehistoric times, the ancient texts do include descriptions of eye surgery, dating back millennia. Although treatments for cataract and eye trauma were practiced, analgesia was not good, and limited antisepsis meant that many operations failed. Descriptions of treating eye disease through non-surgical methods date back to the Rigveda – the oldest of the North Indian Vedic scriptures, composed around 2000 BC.[1] The great Indian surgeon Sushruta [around 600 BC] established eye and plastic surgery, drawing on and citing previous sources. Sushruta's clinical textbook, "Samhita," contained an 18-chapter tome on ophthalmology, in which he discussed 76 different eye diseases, of which 51 required surgical treatment.[2] For his operations, he described 101

blunt and 20 sharp instruments for surgery. A debate has been ongoing since Duke Elder commented on Sushruta, discussing whether he actually practiced extracapsular cataract extraction or couching.[3] The surviving descriptions in the Bower manuscript stored in the Bodleian library mention an instrument being inserted towards the pupil and the patient blowing down his nose to extrude lens material. This suggests extracapsular cataract removal rather than couching.[4] Sushruta described early antiseptic practices and sedation techniques, including the use of wine prior to surgery. Some sources suggest that herbal substances like cannabis may have been used, though direct textual evidence from *Sushruta Samhita* is limited. References to 'Samohini', possibly a plant-based sedative, exist in later interpretations, although its identification and function remain uncertain. The legendary herb 'Sanjivani' is associated with reviving unconsciousness in mythological texts like the Ramayana, but there is no confirmed historical use in reversing sedation. Unfortunately, the precise recipes for many of these ancient preparations have not survived.[5]

Seemingly, only the Indian knowledge about couching contained in the Sanskrit scriptures was transmitted to China,[6, 7] Persia, Greece, and Rome[8] through translations along the Silk Road. The great Abbasid ophthalmologists, such as Yuhanna Ibn Masawaih (777–857) and Hunain Ibn-Ishaq (808–873), described a hollow tube for removing cataracts by suction, a technique that the Greek physician Antyllus had used in the 2nd century. This technique was improved by the Iraqi ophthalmologist Ammar bin Ali Al Mawsili in the 10th century, who developed a metallic syringe with a hypodermic needle to extract cataracts by suction.[9, 10]

To minimise the pain of surgery, these ancient physicians used analgesic-sedative concoctions combining opioids, wine, cannabis, henbane, mandrake, ephedra, as well as local cooling by ice and inhalation from soporific sponges.

The legendary Chinese surgeon Hua T'o (140-208) is said to have performed cataract surgery after inducing general anaesthesia with "mafeisan", a wine with cannabis admixture on emperor Cao Cao (155–220 CE).[6] These reports may be considered myths, but in 1804 (sic) Japanese surgeon Hanaoka Seishi (1760-1835) performed breast surgery on patients under general anaesthesia.[11] His oral anaesthetic drug "Mafutsusan" was a herbal concoction containing a wide array of potent anticholinergic alkaloids like thorn apple, Chinese Angelica and Japanese aconite. Its use in clinical surgery was discussed in the anesthesiology textbook "Mafutsuto-ron" by Gendai Kamada, a pupil of Hanaoka's, published in 1839.[12] The Ganmoku Shinron by Nakanome, an ophthalmology textbook published in 1850, extensively illustrates cataract surgery; however, information on the use of Mafutsusan for eye surgery is not available.

Ether and chloroform: the first anaesthesia revolution of the modern age (1846)

The introduction of general anaesthesia (GA) with ether in 1846 and subsequently chloroform in 1847 allowed surgery to be performed without restraints, alcohol and opium. Although milestones in ophthalmic surgery (such as von Graefe's iridectomy) were

achieved, ophthalmologists seem to have adopted GA less enthusiastically and often continued to perform sophisticated eye surgery with restraint.[13] Anaesthesia fatalities from both agents were frequent, resulting from asphyxia with overdosing or cardiac arrest during chloroform induction. The ether vs. chloroform controversy was fought out in clinical societies and the press. Specialists in anaesthesia, among them many anaesthesia nurses, only reached specialization gradually and were not easily available. Edouard Meyer in his "Treatise of operations practiced on the eye" in 1871 voiced the prevalent scepticism as follows: "... I don't consider the habitual use of ether or chloroform admissible for cataract operations... one exposes oneself to tumultuous movements of body and head the awake patient would know to control during the few minutes needed for surgery.... furthermore, I consider really dangerous the ...tumultuous agitation accompanying vomiting that so often follows chloroformisation... anaesthesia for .... cataract surgery seems only necessary in patients deprived of the indispensable energy to suffer the operation or those where intense intraocular pressure obliges us to completely abolish muscular contractions...".[14]

Even without complications, before airways were secured by intratracheal tubes, anaesthetists needed to constantly manipulate the face, covering the airway with masks and ether-droppers, wiping saliva, performing jaw-thrusts or tongue mobilisations, as Mayo Clinic's head anaesthesia nurse Alice Magaw reported in 1906 in her "Review of over fourteen thousand surgical anaesthesia". The sensation in the title was left unmentioned. To provide anaesthesia without a single fatality in 14.380 patients was unheard of at the time.[15]

The cocaine craze: the second anaesthesia revolution (1884)

The second anaesthesia revolution, cocaine as locoregional anaesthesia, proved a liberating leap forward for ophthalmic surgery. The first use of a true local anaesthetic, cocaine, was in the context of eye surgery in 1884. The first such description was provided by Karl Koller[16] in the autumn of 1884. The concept of truly pain-free surgery was revolutionary, and cocaine was quickly taken up by ophthalmologists and other surgeons. The latter part of 1884 saw experimentation with different techniques of applying or injecting cocaine, with a flurry of publications in the surgical literature. Indeed, development was so rapid that by the end of the year 1884, a review article[17] summarized essentially all modern techniques of local anaesthesia in eye surgery.

Koller's 'discovery' of the usefulness of cocaine did not occur in a vacuum. The late 19th century was characterized by a frenzy about medical and technical progress, embedded in a subculture of self-experimentation. In this climate, Sigmund Freud's studies on the psychological effects of cocaine, as well as literature reflections in tragic heroes like Sherlock Holmes or Dr Jekyll, attested to cocaine's popularity.[18] An interesting parallel to our times, opioid addiction was rampant, and many hoped that cocaine could effectively treat opioid addiction. Several clinicians before Koller had realized cocaine's potential for numbing tissue, and even suggested cocaine use as local anaesthetic as early as 1880.[5] But only Koller took the drug to the laboratory, where he experimented on frogs' and dogs' eyes, finding their corneas to be insensitive to touch, cut or electrocauterization.[6] This finding

proved revolutionary for ophthalmology and surgery in general. Only one year after the presentation of Koller's results in Heidelberg in 1884, the first spinal anaesthesia using cocaine had been undertaken, and surgeons used the revolutionary local anaesthetic on surgical fields throughout the human body.

The review article by Hermann Knapp in the December 1884 edition of Archives of Ophthalmology[17] illustrates just how quickly the new cocaine anaesthesia was taken up. Koller's lecture had been on September 15th, 1884, and it was reported in the October 11th issue of the American Medical Record and in the October issue of the London Ophthalmic Review. Knapp describes how U.S. physicians did not wait for Koller to publish his findings formally, but "they, without delay, tried the new anaesthetic in every direction, finding for themselves many important facts before Dr Koller's or other European publications reached them". Koller's paper was published in an Austrian journal on October 25th, the same day that Knapp himself published a discourse on cocaine in the Medical Record. Koller had described using cocaine eye-drops (*i.e.* topical anaesthesia) for a patient who required bilateral iridectomy. For the first eye, cocaine drops were used, and the patient "did not react in the least to the operation, said that he had not felt at all the corneo-scleral section... he had felt the seizing and drawing out of the iris, but it had not given him any pain." A week later the same procedure was performed on the other eye, the cocaine this time being omitted. "He pressed and squeezed in such a way that he rendered the operation quite difficult..." Knapp's article, dated 24 December 1884, summarized the techniques of cocaine anaesthesia that had been published in the preceding few weeks. The topical-intracameral technique was described by Dr W.O. Moore, who performed a 'painless' iridectomy having 'injected, after the section, two drops of 2% solution through the corneal wound on the iris surface.[17, 19] Dr Moore also described sub-conjunctival anaesthesia, for a strabotomy procedure (the operation of cutting one or more of the muscles of the eye to correct strabismus), in which he 'dropped six to eight drops on to the conjunctiva and injected six drops under the conjunctiva, over the site of the muscle'.[17, 19]

Dr. Turnbull of Philadelphia described an early form of sub-Tenon anaesthesia during enucleation. After opening Tenon's capsule, cocaine drops were "allowed to flow into the cut" and directed toward the posterior globe by flowing down the blades of curved scissors.[20-22] A few days later, Dr. Cocks described a technique more akin to the modern sub-Tenon's block: using an Anel (lacrimal) syringe, he introduced its tip as far back as possible, keeping it near the globe, to inject cocaine into the sub-Tenon's space and along the rectus muscle sheaths.[19] Knapp himself takes credit for the first retrobulbar injection. Following the instillation of cocaine drops, 'the globe was strongly drawn toward the nose using a forceps, and six minims of a 4% solution (painlessly) injected into the orbital tissue close to the posterior part of the globe'.[17] Thus, within months after Koller's report, most of the major techniques of ophthalmic regional anaesthesia known today had been described, in principle (Figure 1.1).

The positive attitude among ophthalmologists about cocaine prevailed for decades, notwithstanding its tendency to instigate agitation, sometimes tachycardia and seizures.[23] Knapp published a monograph covering nearly 40 years of cocaine experience in the 1920s. Yet, early on, the community was forced to acknowledge the substance's toxicity and the toll it took on both the patients and the clinicians. In the ophthalmology community, the vasoconstriction and pupillary dilation of topical cocaine was a welcome

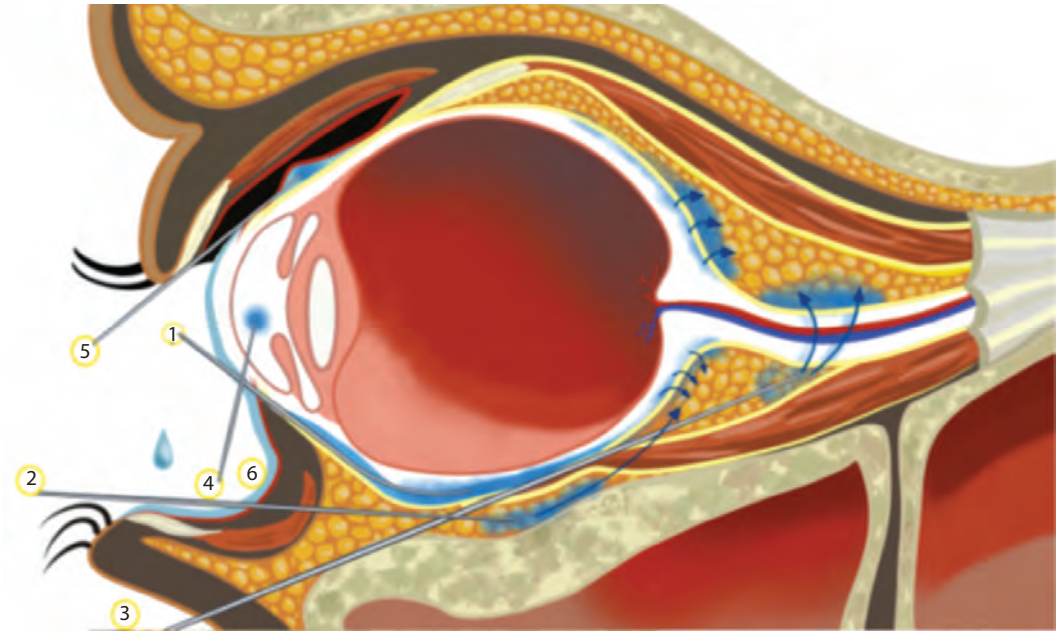

Figure 1.1 Ophthalmic locoregional anaesthesia techniques established during the surgical cocaine-revolution year 1884: 1) sub-Tenon's block (CS Turnbull, DC Cocks); 2) peribulbar block (not described in 1884); 3) retrobulbar block (Knapp,); 4) intracameral application (WO Moore); 5) sub-conjunctival injection (WO Moore); 6) topical (Koller).
Illustration by David Levine, all rights with Friedrich Lersch.

effect not present in the later local anaesthetics like tetracaine. As with some of today's local anaesthetics, good care needed to be taken to close the eyelid after application of cocaine, lest its epithelial toxicity cause a turbid haze to rise on the cornea.

The feared anaesthesia-related fatalities may have helped clinicians be content with applying heavy sedation for eye procedures to safeguard against cocaine complications like agitation, hallucination, tachycardia, profuse sweating and seizures. Later, newly developed local anaesthetics, initially esters like cocaine, and later amide local anaesthetics, were adopted notwithstanding their shortcomings in pupillary dilation and vasoconstriction: procaine (ester) in 1904, tetracaine (ester) in 1928, lidocaine in 1948, and bupivacaine in 1963, to name a few. Adopting these drugs led to new observations and new problems.[24] It may well be that before the first description of the oculocardiac reflex by Aschner and Dagnini in 1908, the resulting arrhythmias of surgical eye interventions were wrongly ascribed to cocaine cardiotoxicity.

By the 1930s, retrobulbar blocks were established practice for much intraocular surgery, including cataract surgery. Walter Atkinson developed the concept of "ciliary ganglion blocks".[25] As the results of these blocks improved, a concept of "intraconal blocks" was fostered and remained unchallenged for 40 years. It was assumed that orbital fascial septa outline a 'conus' containing most of the ophthalmic nerves, and that only injection into this cone provided sufficient regional anaesthesia. Although this concept was

disproven by the Dutch anatomist Koorneef in the early 1970s, it remained prevalent and was reaffirmed by ultrasound work well into the early 2000s.[26] It was left to the French anaesthetist Jacques Ripart to demonstrate in human cadaver studies that no benefit resulted from undertaking the risky injection into the cone when compared with the extraconal, peribulbar injections proposed by Davies in the 1980s.[27]

Using a sharp needle to inject local anaesthetics into the orbit is not, of course, without its risks. The long 'retrobulbar' needles put patients at risk of blindness (caused by a needle in the eyeball, a needle in the optic nerve, or a severe orbital haemorrhage). Atkinson's 'up and in' globe position would bring the macula into the path of the needle tip, particularly for longer (myopic) eyes. In addition, if the needle were to pierce the coverings of the optic nerve, the injectate could go straight back to the brainstem, potentially causing death. As will be explained later in this book (Chapter 9), the use of shorter needles and altered needle positions has helped to minimise these risks. One significant advance was the concept of 'peribulbar' as opposed to 'retrobulbar' blocks, which means that the needle is aimed outside, rather than inside, the muscle cone.[27] Despite these (and other) adjustments to technique, the inherent risks of needle blocks remain.

Although heavy sedation often accompanied eye surgery under retrobulbar blocks in the first half of the 20th century, most surgeons and anaesthetists thought of the necessary anaesthesia in "either GA or regional"-dichotomy. With the advent of secured airways through hypopharyngeal or tracheal intubation, ophthalmologists gained freedom of movement in the face without persistent interference by anaesthetists. From 1908 onwards, when Hewitt gained access to the hypopharynx with his oropharyngeal tubes, and continuing through the 1920s and 1930s with Guedel's and Waters' cuffed tracheal tubes, progress in laryngoscopy led to general anaesthetics becoming much safer. Potentially inciting strong brainstem reflexes through pharyngeal, laryngeal, or tracheal placement of these airways, clinicians are obliged to safeguard ophthalmic patients against coughing or retching during sensitive surgical phases when movements or intraocular pressure swings can cause significant harm. This led to GA for eye surgery as very "deep" anaesthesia with its own postoperative complications like delayed awakening, nausea and vomiting with concomitant intraocular pressure swings and suture failures, postoperative delirium and emergence delirium. Combining general anaesthesia with regional anaesthesia to mitigate the harmful effects on the central nervous system was extensively studied by trauma surgeon George Crile in the early 20th century.[28] His astonishingly modern concept of "anoci-association" was proven in animal studies to result in severe histological damage of the cortex from high-dose exposure to ether or chloroform. This was not present when a perineural nerve block or spinal anaesthesia was performed, and GA was administered accordingly. This concept of combined anaesthesia was explored in adults' eye surgery by Bergman *et al*.[29] and in children by Chhabra *et al*.[30]

The advent of small-incision phacoemulsification in the 1980s-90s meant that akinesia (immobile eye) was no longer an absolute requirement for cataract surgery. Topical anaesthesia (eye-drops or gel alone), often combined with an irrigation of preservative-free lidocaine into the anterior chamber (topical-intracameral anaesthesia) techniques, has become the standard technique for phacoemulsification in many parts of the world. Using topical/intracameral anaesthesia for this sort of surgery is quick, safe, and well-tolerated, though it is not suitable for all surgeries. For operations that require an immobile eye (*e.g.*

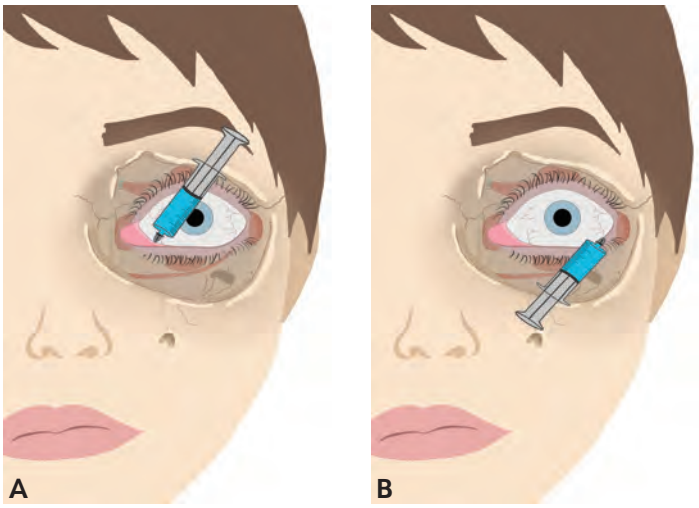

Figure 1.2 Historically, 2 access localisations for eye blocks proved most effective. Inferonasal access (A) used both for sub-Tenon with blunt curved cannulae (Stevens) and tangential, sharp-needle sub-Tenon's as described by Ripart. The semilunar fold helps to gauge distance from the limbus. The axis of injection aims to keep distance from both rectus inferior and medial muscle. Inferotemporal injection (B) is most often used for peri- and retrobulbar blocks. Historically the upper quadrants are avoided for sharp needle blocks due to dense vascularisation.

most vitreo-retinal surgery, penetrating corneal grafts, some glaucoma surgery) a 'block' is felt to be much safer.

In the final decades of the 20th century, as surgical techniques became significantly less invasive, efforts were made to minimise the risks associated with the retrobulbar block. Davies' publication of the peribulbar block and Stevens' re-introduction of sub-Tenon's anaesthesia were both important efforts in this direction.[31] During the same time, in the 1990s, regional anaesthesia developed at a swift and enthusiastic pace. Following the initial publication of Doppler ultrasound for avoiding blood vessels in supraclavicular plexus blocks, clinical ultrasound technology rapidly evolved to be applied at the bedside.[32] A group of anaesthetists and radiologists from Vienna published their results in 1994, based on a study of 40 patients using ultrasound-guided supraclavicular brachial plexus.[33] Around this time, ultrasound was also adopted to improve the safety of sharp-needle blocks.[34] The pressing question as to whether ultrasound caused damage to the eyes undergoing regional anaesthesia was answered through an animal study 20 years later.[35] It was found that 'standard' ultrasound probes, used by anaesthetists for regional blocks, could indeed damage the eyeball by heating; therefore, special (eye-rated) ultrasound probes are now used for eye anaesthesia (Figure 1.2).

Around 1990, sub-Tenon's block (STB) was reintroduced. These 'fascial plane' blocks use a blunt-ended cannula to place the anaesthetic between the globe (sclera) and the surrounding Tenon's capsule. This anatomical plane is reached by making a small hole in the conjunctiva, classically about 5-6 mm behind the limbus. Sub-Tenon's blocks have the advantage of having no needle, and therefore the risks of 'needle in eye, needle in optic nerve' are negated. The technique is not entirely risk-free, as explained later in this

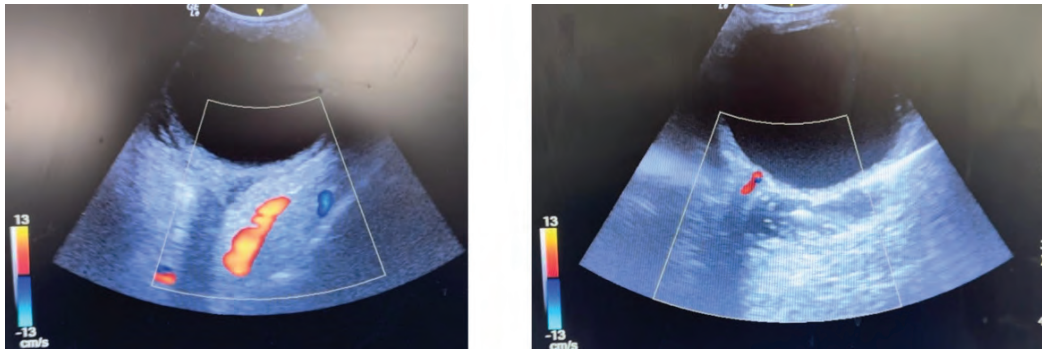

Figure 1.3 Overview anatomy in ultrasound guided peribulbar block: orbital wall, blood-vessels and the optic nerve are visible behind the bulb (left vignette). The needle trajectory and local anaesthetic deposit (T-sign) are well outlined in the right vignette. Training and experience in the use of ophthalmic ultrasound can increase safety in the application of sharp-needle blocks. As in other regional anaesthesia blocks, inline visualization of the needle can prevent harmful contact to sclera, orbital vessels and the optic nerve.
Illustration courtesy of Dr. Lucie Beylacq, Bordeaux, France.

book (Chapter 6), but STBs appear to be at significantly reduced risk of sight-threatening or life-threatening complications compared to needle blocks (see Chapter 9). STB has become the 'standard' block in many countries. Indeed, the United Kingdom's National Institute for Health & Care Excellence (NICE) issued an evidence-based guideline in 2017 which stated that, for phacoemulsification cataract surgery, one should 'Offer sub-Tenon's or topical (with or without intracameral) anaesthesia for people having cataract surgery. If both sub-Tenon's and topical (with or without intracameral) anaesthesia are contraindicated, consider peribulbar anaesthesia. Do not offer retrobulbar anaesthesia for people having cataract surgery'.[36]

While sharp-needle blocks continue to be performed as standard in many countries, an increasing number of ophthalmic and anaesthesia societies recommend sub-Tenon's block as the safest ophthalmic regional anaesthesia.[36-38] As in other regional anaesthesia blocks, ultrasound contributes significantly to increased safety in providing ophthalmic blocks in many countries[39, 40] (Figure 1.3).

Conclusions

The outlook for ophthalmic anaesthesia is bright in many ways, even with increasing economic pressures on eye surgery being performed without anaesthetists. With active societies (BOAS, OAS, AIOA, WCOA, etc.) teaching anaesthesia techniques at congresses and courses on various models,[41-44] anaesthetists can be sufficiently instructed to bring increased expertise to ophthalmic operating theatres. Eye blocks can help reduce risks and costs simultaneously, for example, in ophthalmic trauma[45] or the treatment of retinopathy of prematurity,[46] where they have been less widely applied than in routine surgery. Sedation during eye surgery performed under regional anaesthesia remains to be discussed and improved with new drugs on the horizon and the constant demand to