

Globe penetration during loco-regional anesthesia: prevalence and review of cases

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Abstract

• **AIM:** To describe prevalence and different clinical signs and management of cases with penetrating eye injuries during loco-regional anesthesia for ophthalmic surgery.

• **METHODS:** A retrospective review of clinical records was carried out, identifying cases of globe penetration secondary to peribulbar anesthesia injection during 5y activity in Centro de Oftalmología Barraquer.

• **RESULTS:** A total of 17 460 needle-based ocular anesthesia procedures were performed in our centre and 4 cases of globe penetration were recorded with an estimated prevalence of 0.024%. Globe penetrations were always detected in the first 24h after surgery. Vitreous haemorrhage was found in all the cases. Two eyes presented retinal detachment and two eyes choroidal detachment (CD). The initial surgical approach was performed within the first 48h. Silicone oil was used as tamponade in three eyes and the fourth case remained only with air. Detachments were solved successfully in all the cases. Functional results varied among cases, depending on ocular remarkable antecedent and globe penetration with or without retinal or CD.

• **CONCLUSION:** Prevalence of globe penetration during loco-regional anesthesia is low in our centre. Physicians should consider the possibility of globe penetration in eyes with postoperative atypical appearance after loco-regional anesthesia. Immediate B-scan ultrasonography is recommended in suspicious cases with a dense vitreous haemorrhage. An early vitrectomy surgery in conjunction with laser or cryotherapy at the penetration sites is essential for good anatomical and functional results.

• **KEYWORDS:** loco-regional anesthesia; peribulbar; retrobulbar; globe penetration; retina

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INTRODUCTION

Globe rupture of the eye occurs when the integrity of the outer membrane of the eye is disrupted by blunt or penetrating trauma. Globe penetration (entrance only) and perforation (entrance and exit) is a well-recognized though rare complication of local anesthesia for ophthalmic procedures, including peribulbar and retrobulbar blocks^[1-3].

To avoid the necessity for general anesthesia in ocular surgery, blockage of the optic nerve using needle-based blocks is widely implemented to achieve akinesia and analgesia. Complications of the procedure (*e.g.*, haemorrhage^[4], iatrogenic injection of the local anaesthetic into the optic-nerve sheath^[5], penetration of the ocular globe^[6], amaurosis^[7], iatrogenic ophthalmic artery occlusion^[8-9] or brainstem anaesthesia^[10]) are rare. Although these complications may be avoided with topical administration, loco-regional anesthesia is preferred in procedures requiring both akinesia and deep anesthesia.

Historically, penetrating injuries associated with intraocular haemorrhage that occurred during local anesthesia for ocular surgery have been a challenge for ophthalmologists, resulting in a guarded prognosis for the patient's visual acuity. Some series described that none of the patients who presented a retinal detachment (RD) after ocular penetration maintained a final visual acuity better than 20/200^[11]. Described risk factors for globe penetration are posterior staphyloma, long axial length, inexperienced personnel. The use of sharp long needles and the use of multiple injections^[12].

This study analyses the prevalence of inadvertent penetration of the globe during intraorbital injections of local anesthesia over five years at Centro de Oftalmología Barraquer and details the clinical features, management and subsequent course of four cases that suffered it.

SUBJECTS AND METHODS

Ethical Approval This is a retrospective, study of the prevalence and description of cases that suffered penetration of the globe secondary to retrobulbar anaesthetic injection. All cases occurred at our centre (Centro de Oftalmología Barraquer), Spain, between November 2014 and November 2019. The approval of our IRB (Comité de Ética de la Investigación con medicamentos del Centro de Oftalmología Barraquer) was obtained for the retrospective review of the patients' clinical records. This study was conducted in accordance with the tenets of the Declaration of Helsinki.

The review of the clinical records was performed with special attention to the presence of: 1) staphyloma, 2) axial length, 3) refractive error (spherical equivalent), 4) initial and final visual acuity (in Snellen), 5) elapsed time between the administration of the anesthesia and clinical detection of the penetration, 6) type of anesthesia, 7) clinical manifestation of globe penetration [retinal or choroidal detachment (CD), vitreous haemorrhage, inflammation and intraocular pressure (IOP)], 8) stages of the surgical approach, and 9) follow up after surgery were also recorded (Table 1).

Anaesthetic procedures were performed and monitored by qualified and certified medical anesthesiologists with long and well-documented clinical expertise. The Thornton peribulbar/retrobulbar anesthesia sharp needle of 25 mm ×25 gauges (G) was used in each case.

The longer action anaesthetic agents were preferred for vitreoretinal surgery and the shorter for the anterior segment and ocular surface. Using this approach short loco-regional anesthesia was performed by diluting 250 international unit (IU) of hyaluronidase (Wockhardt UK Ltd., United Kingdom) in 6 mL of levobupivacaine (Altan Pharmaceuticals, Madrid, Spain). Three milliliter of the diluted solution are taken and 7 mL of lidocaine (B. Braun Medical SA, Barcelona, Spain) 2% are added. The remaining solution consists of a proportion of 30% of levobupivacaine and 70% of lidocaine in a 10 mL syringe. With this technique, two injections are made. The first injection is given inferiorly with a 25 G needle at the junction of the outer one third and inner two-thirds of the lower orbital rim perfusing 5 mL of the anaesthetic solution and the second injection is given superonasal beneath the superior orbital notch where 3 mL of the solution is injected.

Long loco-regional anesthesia involved diluting 250 IU of hyaluronidase in 4 mL of ropivacaine (B. Braun Medical SA, Barcelona, Spain) and then taking 2 mL of solution, adding 8 more millilitre of ropivacaine, consisting of a 10 mL solution of sole ropivacaine and hyaluronidase. The injection of this anaesthetic of longer duration usually is carried out with the same technique as short loco-regional anesthesia.

All patients underwent a complete pre and postoperative evaluation that included slit-lamp examination, IOP measurement and dilated fundus examination. B-scan ultrasound was

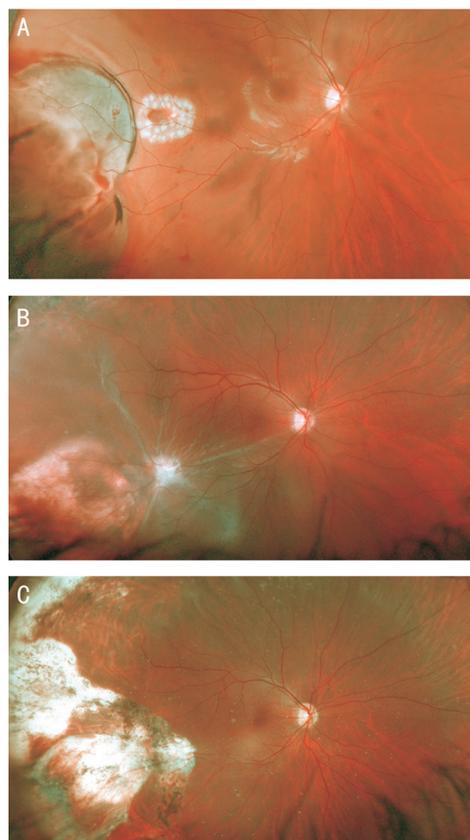


Figure 1 Images of Case 1 A: First day after urgent vitreoretinal surgery. Note the vitreous cavity filled with silicone oil, oedematous PCG around the perforation and a stable subretinal peripheral blood clot. B: One month after silicone oil extraction, the patient presented with a lower RD and PVR. C: Final result one year after cataract surgery, 360° scleral buckle, pars plana approach, endophotocoagulation, cryotherapy and 15% C₃F₈ exchange. PCG: Photocoagulation; PVR: Proliferative vitreoretinopathy; RD: Retinal detachment.

realized in cases in which opaque media complicated an adequate view of the posterior segment. Axial length was measured with IOLMaster 500 (Carl Zeiss Meditec, Jena, Germany). Monocular visual acuity was measured with a Snellen chart in decimal units.

Statistical Analysis The statistical analysis for the prevalence study was performed with the Chi-square test using SPSS (v22, IBM® 2013).

RESULTS

Between November 2014 and November 2019, four cases of iatrogenic globe penetration were identified revising 17 460 needle-based ocular anesthesia procedures. The prevalence was of 0.024%. Below we present a detailed description of each case (Table 2).

Case 1 A 52-year-old man referred to the Emergency Department for blurry vision after a traumatism. His vision, without correction, was 20/25. Eye fundus examination showed a peripheral temporal retinal tear with vitreous haemorrhage (Figure 1).

Table 1 Clinical details of each case before the accidental needle penetration

Items	Case 1	Case 2	Case 3	Case 4
Age	52	63	57	69
Sex	Male	Male	Female	Female
Eye	Right	Left	Left	Left
Axial length, mm	24.87	32.16	29.45	22.67
Staphyloma	No	Yes	No	No
BCVA	20/25 (UDVA)	20/50	20/32	20/20
Spherical equivalent	Unknown	-12.75	-3.88	+2
Ophthalmological history	None	Myopia magna, RD and cataract extraction surgery	RD surgery	None
Initial surgical procedure	Tear cryocoagulation	Dermoid cyst	Cataract extraction	Cataract extraction
1 st injection site	Inferotemporal	Inferotemporal	Inferotemporal	Inferotemporal
2 nd injection site	Nasal	Nasal	Nasal	Nasal
Penetration site	Temporal	Unknown	Nasal	Nasal
Time to penetration noted (d)	0	1	0	1

BCVA: Best corrected visual acuity; UDVA: Uncorrected distance visual acuity; RD: Retinal detachment.

Table 2 Clinical presentation, management and follow up of each case

Items	Case 1	Case 2	Case 3	Case 4
Vitreous haemorrhage	Yes	Yes	Yes	Yes
RD	Yes	No	Yes	No
CD	No	Yes	Yes	No
Surgery	PPV+PCG+silicone oil	Drainage of CD+silicone oil	PPV+PCG+silicone oil	PPV+PCG+air
Time to surgery (d)	0	0 and 10	1	2
Complications	Retinal re-detachment with PVR	No	No	No
Final BCVA	20/40	20/100	20/25	20/20
Follow up (mo)	26	18	12	14

RD: Retinal detachment; BCVA: Best corrected visual acuity; PPV: Pars plana vitrectomy; PCG: Photocoagulation; CD: Choroidal detachment.

A transscleral cryotherapy was indicated to be done in the operation room under long loco-regional anesthesia. After peribulbar injection of anesthesia, the surgeon realized that there was a dense blood clot over the posterior pole coming from the temporal sector of the eyeball, and some blood also located in the subretinal space. On its most posterior part, coinciding with the end of the temporal-inferior vascular arcade, there was a retinal hole with a linear spindle shape. This situation was consistent with an accidental needle globe penetration and complementary surgical approach was consequently carried-out. Pars plana vitrectomy (PPV) was made to clear the preretinal haemorrhage, injection of perfluoro-n-octane, subretinal blood drainage through-the-hole, liquid-air exchange and, and laser photocoagulation (PCG) around the edges of the hole. Blood fluid leaked through the rupture, but a fairly dense and prominent clot remained in the pre-equatorial region. Peripheral cryotherapy was also performed, as planned in the preoperative period. A final exchange to 5000 cSt silicone oil as a tamponade to prevent the retina from re-detach and also preventing displacement of the cloth towards the retroequatorial region was carried-out. The patient did well after surgery and two months later silicone oil extraction was performed. One month after this last surgery

he presented a lower RD with radial fibrosis and contraction around the inferior temporal scar. Cataract extraction with intraocular lens (IOL) implantation, plus a new PPV with the adjuvant use of a circumferential silicone scleral buckle, endophotocoagulation and cryocoagulation and final exchange to 15% C₃F₈ was needed to reattach the retina. Two years later, he presented a best corrected visual acuity (BCVA) of 20/40.

Case 2 A 63-year-old man with myopia magna and a history of RD and cataract extraction surgery, with a documented BCVA of 20/50, underwent the removal of an epithelial inclusion cyst in the nasal conjunctiva in his single eye (Figure 2). The possibility of performing topical anesthesia and subconjunctival injection was explained, but the patient preferred peribulbar anesthesia that was carried out with short loco-regional anesthesia.

The conjunctival cyst was removed without complications. The next morning the patient reported total amaurosis and on examination a yellowish material was observed behind the IOL. B-mode ultrasound scan showed vitreous haemorrhage and an image compatible with CD. Our primary approach was to perform a double posterior sclerotomy and drainage of the hematic content of the CD, with little or no success due to the formation of blood clots. Ten days later, the drainage of the CD

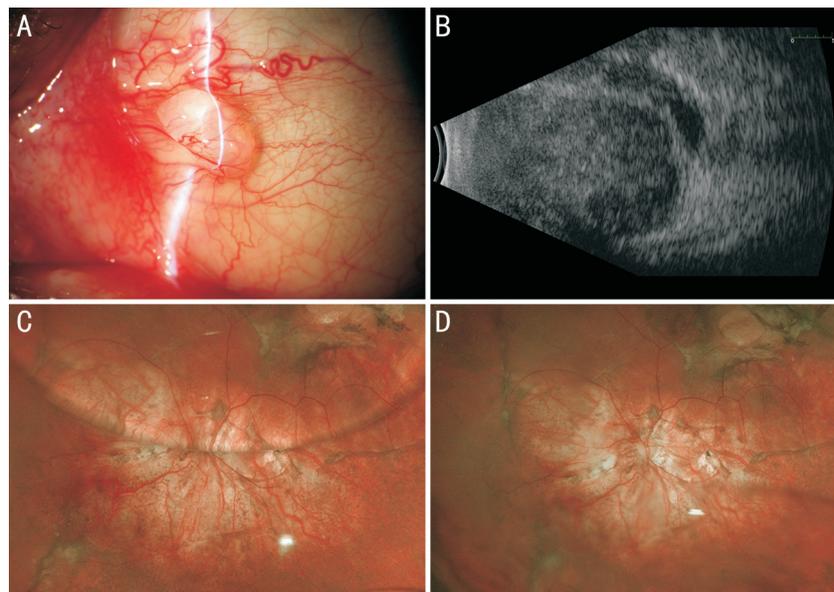


Figure 2 Images of Case 2 A: Nasal epithelial conjunctival inclusion cyst. B: On the day after surgery, the patient presented with total amaurosis and a huge CD filling the whole vitreous cavity (B-scan ultrasound). C: Four months after CD drainage and silicone exchange. After reabsorbing the CD, silicone oil fills 50% of the vitreous cavity. Please note that it is a high myopic eye. D: After removing the silicone oil bubble, the retina remains flat. CD: Choroidal detachment.

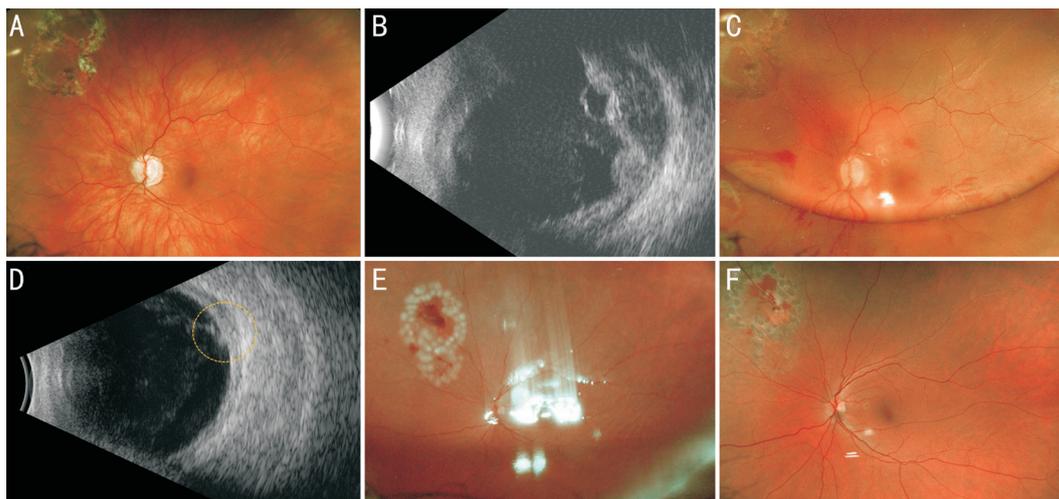


Figure 3 Images of Cases 3 and 4 Case 3: A: Eye fundus before the perforation during cataract extraction surgery. Old laser scars in the superonasal equator. B: Eight hours post-perforation, ultrasound showed a vitreous haemorrhage and an annular peripheral choroidal effusion with large bags. C: Image after 5d of drainage of RD, CD and exchange with silicone oil. Case 4: D: B-scan ultrasound 24h after the ocular perforation showing a vitreous incarceration in the upper-nasal quadrant (circle) and vitreous haemorrhage. E: Flat retina and oedematous laser spots three days after surgery. F: Clean vitreous cavity and laser scars around the hole, one month after the surgery. RD: Retinal detachment; CD: Choroidal detachment.

was repeated and a PPV approach with an exchange to 5000 cSt silicone oil, with satisfactory results because the clots had been lysed. Eight months after the surgery, the silicone was extracted without complications.

In the last control, 18mo after the initial procedure, the patient presented a BCVA of 20/100.

Case 3 A 57-year-old woman with a history of RD in the left eye, who had been treated without complications one year before, achieving a BCVA of 20/32, underwent cataract

extraction plus IOL implantation using short loco-regional anesthesia with no difficulties (Figure 3A-3C).

Eight hours after surgery, he returned to the Emergencies Department presenting a painful red eye and severe loss of visual acuity. On examination, conjunctival nasal chemosis, hematic remains in the anterior chamber and vitreous turbidity were observed. The B-mode scan showed both retinal and CD. Twelve hours later, a PPV approach was made, clearing the entire vitreous cavity, observing an annular peripheral

choroidal effusion, a penetration that crosses the nasal retina and a retinal rupture immediately below the lower temporal arcade with a blood clot beneath it. PCG around peripheral retinal tear and silicone oil exchange for tamponade was made. One year after surgery, BCVA of the patient was 20/25 with no choroidal or RD. Silicone oil removal is planned for the near future.

Case 4 A 69-year-old woman underwent cataract extraction and IOL implantation in the left eye with short loco-regional anesthesia without apparent complications (Figure 3D-3F). Her documented prior BCVA was 20/20.

The next morning, the patient presented to our office with a BCVA 20/200, no pain, IOP of 15 mm Hg and haemorrhage in the vitreous cavity unable to observe the posterior pole or the peripheral retina. In B-mode ultrasound scan, an image of vitreous incarceration was diagnosed in the superior nasal quadrant without RD.

On the next day, PPV was performed; vitreous incarceration along a scleral wound with retinal and subretinal haemorrhages was observed. The location of the scleral wound was observed in the same location where anaesthetic was injected. Endophotocoagulation around the retinal wound and exchange with fluid-air was performed, no special tamponade agent (gas or silicone oil) was used in this case. Fourteen months after surgery, the BCVA is 20/20 with no further injuries and an applied retina.

DISCUSSION

During the five-year period of this study a total of 17 460 needle-based ocular anesthesia procedures were performed at our centre. Anesthetic methods for ocular surgeries include general anesthesia and local anesthesia. The majority of eye surgeries are performed under regional anesthesia. This type of anesthesia includes different sub-types, such as topical anesthesia^[13-15], subconjunctival anesthesia^[16-18], retrobulbar anesthesia, peribulbar anesthesia, sub-Tenon's anesthesia^[9,19-20], medial canthus episcleral anesthesia^[21] and facial nerve block. Topical anesthesia has become a common form of anesthesia; however, it requires that the surgery is performed quickly and efficiently to minimize stress on the patients^[22], patient cooperation^[23], experienced surgeon^[10] and it doesn't provide the same level of pain relief as peribulbar anesthesia^[24-25]. We still prefer loco-regional anesthesia not only for posterior segment or glaucoma surgery but also because it is the preferred method for anterior segment surgery. This procedure includes corneal transplantation and IOL implantation for both refractive (implantable collamer lenses and multifocal lenses) and cataract extraction. Loco-regional anesthesia is the only technique that reaches both akinesia and deep anesthesia without complications of general anesthesia^[26-27]. Consequently, it is performed in the 90% of the surgeries in our centre.

Peribulbar anesthesia consists of one or more injections of local anaesthetic around the globe avoiding the muscle cone. In this technique, the needle is not introduced within the orbit as obliquely as with retrobulbar anesthesia. This means, in theory, that peribulbar anesthesia carries less risk of inadvertently penetrating vital structures^[28-31]. However, this method has poor efficacy in terms of achieving akinesia after a single injection and the need for a second injection is needed, increasing the risk of ocular complications^[7].

Needle penetration of the globe during loco-regional anesthesia is a rare hazard. The percentage of globe penetration/perforation in peribulbar and retrobulbar blocks have been reported in the range of 0.0062% to 0.022% and 0.007% to 0.075%, respectively (data from sample sizes equal or longer than 1000 eyes)^[3,32-34]. Our estimated prevalence of 0.024% falls within the range described.

Described risk factors for globe penetration include posterior staphyloma^[34], long axial length^[11], inexperienced personnel^[35] and uncooperative patients^[23]. In our study, two eyes had myopia. From these, only one had posterior staphyloma (Case 2) and two eyes (Cases 2 and 3) had an axial length longer than the average, 32.16 mm and 29.45 mm respectively. The present study gives strong support to the hypothesis that axial myopia is a definite risk factor for globe penetration. Despite being eyes with staphyloma and high myopia that is the riskiest, some risk in normal axial length cases cannot be ruled out.

In our centre, all the anesthesiologists have had at least 10y of clinical expertise in ophthalmic retrobulbar anaesthetic procedures. In despite of this, as in other published studies, globe penetration after peribulbar anaesthetic procedure could occurred with trained and experienced personnel^[9]. Some authors describe that ultrasound guidance can be used to conduct locoregional anesthesia. Ultrasound can be used to guide needle placement^[36-37], to minimize the volume of local anesthetic by using the globe axial length measurement^[38] and to train young anesthesiologists or ophthalmologists^[39].

Some features of the administration technique of the anaesthetic drugs such as the use of sharp long needles and the use of multiple injections have also been described as risk factors for ocular penetration. In the current study, a sharp needle was used in each eye. Specifically, in our affected cases, the Thornton peribulbar/retrobulbar anesthesia a 25 G×25 mm sharp needle was used. Previous case series have also reported globe penetration using blunt needles, probably because other risk factors were present or simply due to imponderable elements related to any medical act or decision^[40-43]. It is worth mentioning that, to minimize risks, our centre has switched to a shorter 25G Atkinson needle with a blunt tip and 22-degree bevel.

Concerning the number of injections, Ball *et al*^[44] defended that a second injection may increase the risk of penetration

especially if it is placed immediately after a first injection on the opposite side, due to globe displacement. Other authors expose that an adequate block can be achieved with a single peribulbar injection, lowering the risk^[40,44-46]. Other authors propose a modified entry location to reduce penetration risk^[3]. In addition, it is believed that shorter needles may reduce needle-related complications. In fact, traditionally, a 3.8 cm needle was used in most published studies. In the last few years, shorter 2.5 cm needles had been used^[47], while some authors claim excellent results with a 1.5 cm needle^[48-49]. There is little discussion about which is the most suitable calibre for the injection needle, although 25 G is preferred. Some anaesthetists use 30 G needles, but many find them too flexible^[47]. Regarding the described prognosis factors, outcomes were related to: 1) early recognition, 2) absence of RD, and 3) site of penetration^[12,32,50-53]. In the present study, Case 1 had the worst outcome and developed a severe proliferative vitreoretinopathy (PVR) with resultant re-detachment of the retina, probably due to the presence of subretinal hemorrhage and the intensity of the laser that we had to apply around the iatrogenic rupture, which could induce more inflammation and a PVR that evolved to form a contraction star. Functional results varied among cases: Case 4 had complete visual recovery (final visual acuity of 20/20) without ocular remarkable antecedent and globe penetration without retinal or CD. It is worth mentioning that no cases of globe perforations (entrance and exit) were found. In our study, all patients had a relatively good outcome due to early recognition and treatment. B-scan ultrasonography is recommended in every suspicious case with dense vitreous haemorrhage, applying little pressure to the ocular globe when considering a probable penetration. When dense vitreous haemorrhage with no RD is present, quick removal of the haemorrhage together with PCG or cryotherapy around penetrating injuries may prevent RD secondary to vitreous traction and PVR. When an RD is detected in a case with ocular penetration, a standard RD surgery with drainage of subretinal fluid and the use of silicone oil tamponade could be better. Silicone oil tamponade allows us also to compartmentalize the vitreous cavity avoiding the free diffusion of inflammatory factors that would increase the risk of a new RD. When a CD is detected, two alternatives could be chosen. One of them is the use of drainage sclerotomies directly made with 45° sharp knife, left open to the sub-Tenon space, which is our first choice when CD is extensive, and no visualization of the posterior pole could be made, or kissing pattern of the CD is visualized on B-mode ultrasound scan. When posterior pole visualization is correct and especially if an RD is also detected, a PPV approach with silicone oil tamponade could be recommended. The only use of silicone oil is enough for these patients to maintain the retina on its

place and serves to give time for the CD to be reabsorbed. Finally, it is important to warn these patients about the possibility of visual disturbances and discomfort. When the CD is reabsorbed the silicone oil bubble will not change its size and space previously occupied by the CD will be filled with new synthesized aqueous, creating a liquid-silicone interface between these two different refraction index media.

In conclusion, the ideal anesthetic technique would: 1) minimize risks to the patient, 2) guarantee total comfort throughout the procedure, and 3) give perfect operating conditions for the surgeon. At present, there is no technique to produce akinesia and eye analgesia with absolute certainty and irrevocable safety. Peri and retrobulbar blocks are a good choice that reduce other described risk factors of the administered technique. If penetration of the globe occurs in needle-based blocks anesthesia, early diagnosis and treatment of ocular penetrations are essential for a good visual outcome.

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