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Intraocular Gases as Tamponade in Retinal Surgery

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Abstract: *Intraocular gases have been an important part of vitreoretinal surgery for the past 40 years. They can be used both with and without vitrectomy. Certain criteria are required for an intraocular gas to be useful enough with the least side effects. However, use of diluted gases with air can make the injected gas more likely to be tolerated by the eye. Some side effects will still happen due to the mechanical effect of gas bubble such as touching the lens which will lead to cataract.*

1. Introduction

Intraocular gases are very important tools of tamponade following vitrectomy. Air was the initial gas to be used in vitreous surgery. Newer gases were introduced that are in most cases more practical and provide longer term tamponade compared to air [1]. Sulphur hexafluoride (SF6), hexafluoroethane (C2F6) and perfluoropropane (C3F8) are the most commonly used gases in pneumatic retinopexy (PR). A variety of gas products has been investigated for intraocular use. Among the properties of gas selection are; availability, expense, bioavailability and safety, stability when mixed with air as well as longevity. However, there is no single gas product that has all the properties that makes it ideal for tamponade. An efficient gas bubble should provide enough buoyancy to float upward and adequate surface tension to close a tear and prevent the bubble from going through the tear in order to effectively isolate a tear from intraocular current [2].

2. Discussion

Air, although not very commonly used nowadays, helped eyes filled with it following vitrectomy to remain pressurized and tamponade for 5-7 days. Air has the advantages of being cheap and non expansile; a criterion that reduces the risk of traction on the inferior retina and creating new tears in non vitrectomized eyes. As air bubble does not expand such as the case with other gases, no displacement of the gel or subsequent traction on the vitreous base inferiorly is like to happy [3]. Another advantage of air injection in scleral buckling surgery is reducing the need for large freeze ball as it makes the retina opposite to the choroid at the site of the retinal tear reducing the need to freeze through a high subretinal fluid. The tamponade effect is required for the duration the retina and choroid develop their own adhesions and seal the tear. Disadvantages of air include criteria innate to air such as short longevity and other complication related to bad injection technique which can result in fish eggs due to breaking up of the air bubble. Although air was looked down at due to these "imperfections" at a time cryotherapy was perhaps the only way available to a vitreoretinal surgeon to seal a retinal break, it is regaining popularity at a time endolaser is more commonly used. Therefore, in such a day and age where endolaser is what creates chorioretinal adhesions, a period of 5-7 days is a good enough period of tamponade. Obviously, bad injection technique can be worked on to be improved and fish eggs can be avoided. It is nowadays postulated that air is a good source of tamponade if no proliferative vitreoretinopathy is anticipated and the tear is a small one [4].

Sulphur hexafluoride (SF6), hexafluoroethane (C2F6) and perfuoropropare (C3F8) are less water soluble and tend to remain within the eye for longer. Moreover, Oxygen and Nitrogen in the surrounding tissues tend to diffuse into the gas bubble more than they do with air. Therefore, the bubble will expand after injection to reach a maximum size before starting to wane off again. The time it needs to do so as well as the maximum size varies between different gases.

SF6 will double within 36 hours while C3F8 will remain to grow and quadruple over a period of 3 days. In the meantime, air will remain about the same size as originally injected. Those gases will remain in the eye for varying periods too. Air will be the first to absorb while SF6, C2F6 and C3F8 will remain in the eye for an average duration of 12, 30 and 38 days respectively. The longevity of intraocular gases can vary depending on the eye and the technique used. They tend to remain more in phakic, non-vitrectomized eyes and those with longer axial length [5]. They also tend to remain longer in eyes vitrectomized using 20-gauge vitrectomy compared to smaller gauge probes [6].

3. Intraocular Pressure Elevation

The risk of intraocular pressure rise following intraocular gas injection can mount up to 59% [7]. The pressure rise is normally transient and last for a week postoperatively with highest mean rise last for two to four hours [8]. Use of pressure lowering drops can be advisable in eyes with glaucoma or ischemic retinal nerve fibers for any other reason [9]. Intraocular pressure rise risk is more in older patients [10] and in cases were concomitant scleral buckling was carried out. In older patients decreased scleral elasticity as well as ocular fluid circulation are to blame on the pressure rise [8]. In eyes with concomitant scleral buckling pressure on the episcleral veins is the main reason for the same complication [10]. Although, intraocular pressure elevation in vitrectomized, especially diabetic, eyes are common due to various factors including long term ischemia, it can be related to gas tamponade. The gas bubble may cause angle closure due to displacement of the iris lens diaphragm anteriorly [11]. In situations like that face down position can help prevent angle closure due gas bubble displacing the iris lens diaphragm.

A significant increase in pressure can result from situations where patient is exposed to inhalation anesthesia as in the form of N_2O. Nitrous oxide gas flow down it concentration into the eye causing the pressure to rise above the level of central retinal artery pressure [12]. The expansile nature of gases can be modified by mixing them with air [13]. SF6, for example, can be rendered non-expansile by diluting it with air using 20% of the dilute as SF6.

There are reports of increased eye pressure that led sometimes to blindness due to gas bubble expansion when person with a residual gas bubble following vitrectomy reached high altitudes either flying in a pressurized cabin or mountaineering [14, 15]. In both cases blindness or temporary loss of eye sight was blamed on central retinal artery occlusion.

4. Cataract Formation

Cataract development following gas tamponade was reported due to contact between the gas bubble and the crystalline lens [16]. However, if the contact for several days is the reason for cataract as claimed by researcher, face down positions which minimize this contact should help prevent such complication. Positioning has been advocated to have many values after gas injections both in vitrectomized and non-vitrectomized eyes. Surgeons also can aim at leaving a thin layer of anterior vitreous as a barrier between gas bubble and the lens. Cataract is more likely to develop is eyes two thirds, or more, full of gas specially with higher purity and longer longevity [17].

5. Conclusion

Air was by far the first gas to be injected into the eye for tamponade. The innate property of air limited its use and led to the introduction of longer acting gases. Although those helped a great deal specially with the duration they remained in the eye opposite to the tear, they also caused significant side effects such as cataract and in some cases loss of vision due to rise of eye pressure. Nowadays it is not unreasonable to think air was not bad after all as it remained a safe way of tamponade with a duration not too short to create the required chorioretinal adhesions, not too long and hence avoiding cataract formation and not expansile to cause any retinal tears in nonvitrectomized eyes or raised IOP is vitrectomized ones.

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