Case report

Management of orbital emphysema secondary to rhegmatogenous retinal detachment repair with hyperbaric oxygen therapy

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A B S T R A C T

Purpose: To describe the case of orbital subcutaneous emphysema who was successfully treated with hyperbaric oxygen therapy.

Observations: Case report. Retrospective analysis of medical records and computer tomography images. A 40 years-old female, with retinal detachment who was seen at the emergency department, two weeks after undergoing a combined procedure of pars plana vitrectomy, scleral buckle and Sulfur hexafluoride tamponade. The patient complained of pain, decrease eye movement and edema of the upper eyelid. Clinical examination revealed periorbital crepitus. She was treated immediately with soft tissue decompression with small-gauge needle. Orbital emphysema recurred quickly, indicating possible gas trapped in the soft tissue. Using the US NAVY decompression protocol we were able to achieve fast clinical improvement. The protocol was repeated in several occasions until complete resolution.

Conclusion and importance: Hyperbaric oxygen therapy is an effective treatment for orbital and peri-orbital emphysema, due to its property of helping accelerate N2 elimination from adipose tissue.

1. Introduction

The introduction of gas tamponade in vitreoretinal surgery is without a doubt one of the most important contributions to the retina specialist’s surgical armamentarium [1,2]. The primary purpose of using gas in retinal detachment surgery is to take advantage of the surface tension created on the bubble’s walls after being placed on a fluid-filled cavity; which produce an internal physical blockage of the retinal tear, preventing fluid from gaining access to the subretinal space. In addition, it creates a buoyant force which helps displacing the retina gently toward the retinal pigment epithelium [1,2].

Sulfur hexafluoride (SF6) is one of the most widely used gas tamponade worldwide. It is a colorless, odorless and nontoxic gas; is five times heavier than atmospheric air and has a molecular weight of 146 g/mol. Although it is chemically inert, it can expand 2 times its original volume when used 100% pure into the vitreous cavity. It has a non-expansile concentration of 18%, a half-life of 2.5 days and a total lifespan of about 15 days [13,4].

As with other surgical devices, the use of SF6 tamponade has potential adverse effects; being orbital subcutaneous emphysema (OSE) one of them. It is characterized by the abnormal presence of gas bubbles within the orbital and peri-orbital tissue [5]. Even though most of the times is self-limited and has a benign clinical course with spontaneous resolution in about 2 weeks; there are more severe forms in which the build-up pressure within tissue can cause a localized compartment syndrome with tissue destruction, central retinal artery occlusion and irreversible vision loss if not immediately decompresses [6–8].

Hyperbaric oxygen therapy (HOT), as defined by the Undersea and Hyperbaric Medical Society (UHMS), is a therapeutic intervention in which the patient breathes almost 100% oxygen...
Orbital cellulitis was suspected and therapy with empiric intravenous antibiotics was started.

One week later (postsurgical day 14), the eyelid edema increased and palpebral and periorbital crepitus was noted. Urgent CT scan was performed using 1 mm slices with a soft tissue and bone algorithm (Fig. 2). The study showed large amounts of gas (palpebral, subconjunctival, retrobulbar and compressing the optic nerve and causing exophthalmus) in the orbit and in anterior chamber. There were no evidence of gas in the vitreous cavity, however, the retina remained attached.

Surgical decompression with fine needle insertion and aspiration along with scleral buckle removal was done immediately. No gas leakage was detected at this time. After surgery, the patient recover partially, regaining ocular motility and less proptosis (Fig. 3). However, gas started collecting again in the retrobulbar and orbital space; requiring several more decompressions with fine needle aspiration (x6) and even a gas-fluid exchange. Every time with partial recovery and relapse shortly after. Without a clear gas origin and since it seemed to be trapped in the soft tissue; we decided to enhance its elimination by using HOT. Using the USNAVY decompression protocol, we started therapy 39 days after the first surgery. HOT profile was 3.0 ATA for 300 minutes with 2 five-minute air breaks at 30 minutes intervals, divided in ten sessions (one per day). Clinical improvement was fast and significant with almost total resolution of proptosis and control of intraocular pressure (Fig. 4). The HOT protocol was repeated as soon as gas start collecting again in the retrobulbar and orbital space on CT scans; or if the patient referred recurrence of the clinical symptoms; twenty five additional sessions with the same protocol was needed (35 sessions total). Four months after initial surgery she had total resolution of the symptoms and 20/60 of visual capacity. Although control CT scan still showed 1–1.5 cc of intraconal gas. Eighteen months later, the patient is 20/60, has an attached retina and total resolution of the orbital emphysema (Fig. 5).

3. Discussion

The kinetic of gas tamponade is complex and has three phases: bubble expansion (driven by nitrogen [N2]), equilibrium of nitrogen concentration and bubble clearance [1]. About 10% of the gas bubble is made of carbon dioxide and oxygen; which remain at constant concentration at all time. The volume of the bubble gradually decreases as all the gases are absorbed at the same rate. Because the longest-acting gas is the slowest to being absorbed, it controls the rate of bubble clearance in the final stage [2,3]. Additionally, the half-life of the gas bubble is influenced also by other factor like the volume of gas injected and concentration, its molecular weight, diffusion coefficient, water solubility, the intraocular pressure, the posterior choroid venous concentration of the gas and the vascular perfusion rate of the choroid.[2,10].

According to a basic principle described by John Scott Haldane in the early 1900s, gas saturation rate varies depending of the tissue and that N2 is 4.5 times more soluble in fat than in water. This means that if fat and water are exposed to the same concentration of N2, the gas will dissolve into both compartments at the same rate but it will take 4.5 times longer for the N2 in the fat to equilibrate concentration with the surrounding gas and when it does, the fat will contain 4.5 times more N2 than the surrounding water [12]. Since most of the tissue in human body has a solubility for N2 similar to water except for fat; the absorption of nitrogen/inert gas by tissues is determined by the cardiac output. However, it will vary according to the tissue’s specific blood flow and its fat content. Usually, adipose tissue has an extremely limited blood flow,
therefore \( N_2 \) rises very slowly on fat, it serves as storage and takes a very long time to eliminate the absorbed \( N_2 \) [12,13].

Although the reason of gas expansion and accumulation in orbital and periorbital adipose tissue in our case is unknown; one possibility is that instead of \( \text{SF}_6 \), a mixture of 18% octafluoropropane (\( \text{C}_3\text{F}_8 \)) was used. At that dilution, the gas gradually expanded eventually leaking through sclerotomies as microbubbles toward the periorbital and intraconal space. Where due to the presence of orbital fat and slow metabolism of \( N_2 \); the gas coming from the vitreous cavity accumulates in great amount without reabsorption. This would explain the constant recurrences of gas despite repeatedly decompressions with fine needle aspiration and the later success of HOT. Despite there is no prior experience regarding treatment of subcutaneous emphysema with HOT; we observed that the behavior of the gas was similar than in decompression sickness. Therefore, using USANAVY decompression protocol was logic and justified.

4. Conclusion

The use of gas as tamponade agent in vitreoretinal surgery has been extensively studied. Although the gas dynamics, expansion properties, diffusion and resorption in the vitreous cavity is very well known; a different behavior can be expected if the gas gains access to the periocular space, mainly due to presence of adipose tissue and a slow \( N_2 \) metabolism. Sutureless sclerotomies may be the escape route of gas. A key step of the surgery is ensuring that the proper gas and proper dilution is going to be used. Despite the fact that there are some previous reports of orbital emphysema secondary to intraocular gas tamponade, the current report
Fig. 3. Upper image (A) was taken after first needle decompression. The patient improved mildly. Few days later, gas began collecting again and more decompression were performed (B). Red arrow indicates the site of repeated needle decompressions.

Fig. 4. A: Clinical photograph, frontal view, taken 24hrs after the first hyperbaric treatment. An important decrease in eyelid emphysema can be seen. The patient showed a better eyelid opening, with less pain and better eye movements. B: 24 h later, the gas started collecting again quickly. C & D: Axial and coronal sections, soft tissue window; obtained after hyperbaric treatment. The scans shows less amount of gas, although complete resolution was achieve after several hyperbaric sessions.
describe a case of greater severity that did not respond to traditional management. The successful use of HOT was because it helped to accelerate \( \text{N}_2 \) elimination from adipose tissue, leading to a shrinkage of the gas bubble contained in the periocular space, avoiding further irreversible lesion to structures like the optic nerve.

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