Title : INTERACTION OF INTRAOCULAR SF_6 AND AIR WITH NITROUS OXIDE

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Introduction. The purpose of this study was to determine the influence of nitrous oxide (N_2O) anesthesia on changes in the size of an intravitreal gas bubble over a period of time.

Methods. A Hewlett Packard HP 9845A computer was programmed to simulate the diffusion of intravitreal gases using a model based on Fick's law of diffusion. It has been observed that the gas bubble is eccentrically located in the vitreous body and is separated from the retinal blood supply by only a thin shell of tissue.[1] The solubilities and diffusivities of the gases in the vitreous was assumed to be the same as in water since the vitreous is 99% water. The effective diffusion distance and retinal blood flow parameters were derived by fitting the model to the experimental data of Abrams et al.[2] Solutions were generated for each of three injected gases: air, 100% SF_6 and the "equilibrium" mixture of 40% SF_6 with 60% air.[1] The influence of N_2O anesthesia on each gas injected was evaluated for three clinical situations.

Results. In the presence of a 70% N_2O steady state, the air, SF_6 and equilibrium mixture gas bubbles rapidly expand, within one hour, to 2.85, 3.25 and 3.00 times their original volume respectively. When the 70% N_2O was changed to 100% O_2 for one hour, the air bubble shrank to its original volume within forty minutes, the equilibrium mixture returned to its original volume by one hour, and the SF_6 bubble diminished to only 1.25 volume minimum at one hour. For the next two hours O_2 was replaced by air. The air bubble continued to decrease in size, reaching 0.75 volume, the equilibrium mixture remained constant at original injected volume size, and the SF_6 bubble began to slowly re-expand, reaching 1.50 volume by two hours. When the N_2O is replaced by 100% O_2 at the time of injection, the air and SF_6 bubbles expand to a maximum of 1.30 and 1.35 times original volumes respectively, within 11 minutes of injection, and then diminish slowly until, one hour after injection the respective volumes are 0.89 and 1.12 times original. If N_2O is discontinued 15 minutes before intravitreal injection, the maximum volume changes are 1.15, 1.17 and 1.20 times injected volume for air, equilibrium and SF_6 respectively. These maximums occur within twenty minutes of injection after which the bubble size diminishes slowly until, one hour after injection the respective volumes are 0.89, 1.00 and 1.12 times original.

Discussion. SF_6, an inert gas is diffusion limited by its high molecular weight, and remains in the eye for 5-7 days.[3]

When an intravitreal air bubble is used in the presence of N_2O, IOP can rise rapidly and significantly reaching a maximum within 24 minutes.[1] In the presence of 70% N_2O, a lcc air injection will reach 2.4 cc size within 30 minutes and 2.85 cc size by 60 minutes. This expansion is even greater when the poorly diffusable gas SF_6 is added to the injection. When N_2O is discontinued, the rapid N_2O washout is reflected in the rapid decline in bubble size when the 70% N_2O is discontinued. A sudden shrinkage of bubble size may be detrimental to the surgical objective. By discontinuing 70% N_2O 15 minutes before an intravitreal gas injection, the N_2O washout is sufficiently complete so that the remaining N_2O will have little effect. There will be at most a volume expansion of 1.20 over a 20 minute period followed by a gradual decline stabilizing at approximately original injected volume one hour later. The intravitreal gas bubble equilibrates with venous blood. The metabolic gases PvO_2 and $PvCO_2$ however, will be fairly constant and will not influence bubble dynamics.[1,2] N equilibrium is a slow process, requiring about 24 hours, so the N diffusion during one hour of 100% O_2 breathing will be insignificant.

The gradual re-expansion of SF_6, reaching 1.5 times injected volume four hours after injection reflects the gradual influx of N but limited efflux of SF_6. Expansion equilibrium in an air breathing patient is reached at approximately 30 hours at which time the bubble contains 18% SF_6 and 76%N[1] and has expanded to 2.8 times its original volume.

Our results confirm that the equilibrium mixture will change very slightly in size and will stabilize at the injection volume, within 60 minutes of injection.

In order to prevent rapid, marked changes in the size of intravitreal gas bubbles it is best to discontinue N_2O anesthesia 15 minutes before the injection. The patient may breathe 100% O_2 for the remainder of the case without significantly disturbing intravitreal gas dynamics.

[1] Fineberg, E. et al: Am. J. Ophth. 79: 67-74, 1975

[2] Abrams, G. W. et al: Invest. Ophth. 13: 863-868, 1974

[3] Constable, I., Swann, D.A.: Arch Ophth. 93: 416-419, 1975

[4] Smith, R. B. et al: Am. J. Ophth. 78: 314-317, 1974