学位論文の要旨

氏名　ANDI MASDIPA

学　位　論　文　名	Flow Pressure Characteristics of the Ahmed Glaucoma Valve and Possible Effect of Entrapped Air in the Tube
発　表　雑　誌　名 （巻，初頁～終頁，年）	Translational Vision Science & Technology (TVST) (**12**(4):16, 2023)
著　者　名	Andi Masdipa, Sachiko Kaidzu, and Masaki Tanito

論文内容の要旨

INTRODUCTION

Glaucoma is the second leading cause of blindness in the worldwide after cataracts. The main goal of treating glaucoma is to reduce intraocular pressure. Surgery is one of the appropriate therapeutic options to treat glaucoma that does not improve with pharmacology treatment. The Ahmed Glaucoma Valve (AGV) is a popular glaucoma drainage device used by surgeons. In surgery, priming is done by injecting physiologic saline of about 1cc with a 26G needle, when the needle is removed from the AGV tube it will make the part that previously contained the needle no longer contains fluid and when this is directly inserted into the eyeball, in this situation it causes air trapped in the AGV tube. This study was designed to measure the pressure characteristics of the AGV and the possible effects of trapped air through an experimental infusion system.

MATERIALS AND METHODS

A total of 17 AGV devices (Model FP 7; New World Medical, Rancho Cucamonga, CA) were tested in this study. A 5 mL syringe attached to the infusion syringe pump will provide flow of physiologic saline to a pressure transducer, then from the pressure transducer physiologic saline will be passed through the infusion tube. Then the 27G needle will be connected to the AGV tube. And in this setting the pressure transducer has been connected to the personal computer through the transducer amplifier and analog to digital converter.

After the initial priming occurs which is marked by the release of physiologic saline flowing through the AGV valve, and at that time the flow of 100 ul/minute is stopped and continues to insert 1 μL of air into the AGV tube, the measurement with the presssure of re-priming air (+) is started by giving a flow of 2 μL/minute, and after that meassure constant pressure after re-priming air (+). The flow of 2 μL/minute of physiologic saline is stopped for about 15 minutes, and re-priming air (-) was started by re-flowing 2 μL/minute of physiologic saline and after that meassure constant pressure after re-priming air (-).

Data were analyzed using statistical software JMP Pro 16 (JMP Statistical Discovery, NC). All data are presented with the mean value and standard deviation (SD). Comparisons between groups of data were tested with paired t-test and unpaired t-test.

RESULTS AND DISCUSSION

Each AGV is measured with 5 pressure characteristics. But in this study the pressure from the initial priming is not included, because in the measurement there are several AGVs whose pressure values exceed the software measurement scale. The mean value of the repriming pressures in the air (+) condition (26.5 mmHg) was significantly (P<0.0001) higher than that in the air (-) condition (12.1 mmHg). In both conditions, the constant pressure after repriming was lower than the repriming pressure (P<0.0001 for both conditions). In contrast to the repriming pressures, the constant pressures after repriming with air (10.6 mmHg) and without air (10.4 mmHg) were equivalent (P=0.68). The repriming pressure with air was higher in old lots (30.5 mmHg) than new lots (23.8 mmHg), a difference that reached borderline significance (P=0.04), while there was no significant difference in other comparisons.

The AGV valve's role is to prevent hypotonia by regulating pressure. It closes when the physiologic saline flow stops or significantly decreases, maintaining a stable pressure in the tube. When the valve was closed and the physiologic saline was re-flowed at the same rate, the pressure continued to increase until it reached a peak to re-open the closed valve. This peak pressure is named the pressure of the repriming air (-) and the increasing pressure can be explained by the water hammer equation approach in pipes.

The pressure of the repriming air (+) condition was about 2 times higher than that of the repriming air (-) condition; thus, the trapped air in tube became an additional factor that increased the valve resistance. The increase in pressure can be explained by complex fluid dynamics since the role of the air in the tube was affected by various factors including the tube diameter and material. Given that the inner tube diameter was in micrometers, the flow was associated with the capillary phenomenon and surface tension. In addition, AGV FP7 is made of medical grade silicone, which is water-repellent. So that all these factors cause capillary pressure, fluid viscosity and trapped air pressure to take the role of increasing the pressure on the repriming air (+).

After priming, the AGV works as a drain where the fluid will flow through the AGV tube and then flow out through the valve. In this condition the AGV works as a venturi with Bernoulli's principle. Given that the air trapped was exhausted at this stage, the constant pressure after repriming should be equal between the air (+) and air (-) conditions, and in fact, our results agreed with the theory.

Intraoperatively, after the initial priming, air can be trapped in the AGV tube when the needle is pulled out of the tube. To avoid the unintended postoperative pressure rise, we recommend that surgeons avoid leaving the air in the tube intraoperatively.

CONCLUSION

Air in the AGV tube causes increased repriming pressure of about twofold compared to repriming without air. This pressure increment caused by air in the capillary-sized tube might occur because of the effects of viscosity pressure and capillary pressure. Although the presence of trapped air in the AGV tube increases the repriming pressure, it does not affect the constant pressure afterward.