Investigating the effect of Polydimethylsiloxane on the preparation of Psyllium and gellan based Ultrasound mediums used in the construction of high-fidelity Regional Anaesthesia training phantoms

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Background

Air is the enemy of Ultrasound guided regional anaesthesia as it thwarts Ultrasound transmission resulting in poor image quality. Human tissue is usually free of air and precautions can prevent its introduction. Such measures would include flushing regional block needles with local anaesthetic so as to eliminate the injection of air, for example.

Over the course of the development of Ultrasound guided regional anaesthesia phantoms we have found the visco-elastic properties needed to produce high-fidelity tissue analogue Ultrasound mediums predisposes them to foaming and air retention during their production. We have investigated a variety of mediums to compare their Ultrasound image quality. Gellan gum and psyllium based Ultrasound mediums can be prone to such a foaming phenomenon during production. Although a high gelling temperature is beneficial in that it ensures gel stability of the Ultrasound medium model, boiling the gel incorporates bubbles which do not fully disperse resulting in foam formation on cooling and setting. We decided to incorporate antifoaming agents to determine whether this occurrence might be prevented and improve consequential image quality.

Methodology

We chose Polydimethylsiloxane a potent and widely used antifoaming agent for our study: Antifoam FDP (Bonneymans, Beith). The gels were prepared with 1:10 mono ethylene glycol/water to create **A**queous **D**ietary fibre **A**ntifreeze **M**ix gel (ADAMgels). Microwave heating and no techniques to prevent foaming were used. First study(S1):We prepared one each of 8% gellan and psyllium ADAMgels with (tests) and without (controls) Polydimethylsiloxane (FDP1:1000). These were then subjected to boiling for one minute and setting. All samples were then examined for consistency, foam formation and Ultrasound image quality. Second study (S2): We then added Polydimethylsiloxane (FDP1:1000) to both controls. All four specimens were re-melted and boiled for one minute to ascertain the effect of adding Polydimethylsiloxane to controls, and if any property changes caused by adding Polydimethylsiloxane to tests were still present after recycling.

Results

There was no tangible difference in the consistency between samples within each group in S1 and S2. Macroscopic foaming were observed in the controls, but not the tests in S1.This decreased in the controls (after adding Polydimethylsiloxane) and increased in the tests in S2. These observations were reflected in the Ultrasound Image Quality (fig 1). However, there is minimal visible difference in the appearance of Aqueous Dietary fibre Antifreeze Mix gels (fig 2 a-d).

Figure 1. Sonographs of Studies 1 and 2 comparing ADAMgel image quality
Inserts showing pristine gels prepared without air entrapment needles in situ

a. Psyllium without Polydimethylsiloxane

b. Psyllium with Polydimethylsiloxane

c. Gellan gum without Polydimethylsiloxane

d. Gellan gum with Polydimethylsiloxane

Figures 2 (a-d). Aqueous Dietary fibre Antifreeze Mix gel with or without Polydimethylsiloxane showing minimal visible difference in appearance.

Conclusion

These studies suggest that the antifoaming agent Polydimethylsiloxane decreases the formation of foam in gellan and psyllium Aqueous Dietary fibre Antifreeze Mix gel (ADAMgels).This enhances Ultrasound image quality and makes the preparation of Ultrasound guided regional anaesthesia phantoms easier.

References

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