Effects of Rheological Factors on Perceived Ease of Swallowing

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Abstract:
This study is a contribution to the understanding of how rheological properties of a fluid influences swallowing, especially people suffering from swallowing disorders (dysphagia). Our hypothesis was that fluid elasticity contributes to safe and pleasant swallowing. In the present study three food grade model fluids with specific rheological properties were developed and used: a Newtonian fluid with constant shear viscosity, an elastic Boger fluid with constant shear viscosity and a shear-thinning fluid which was elastic and had rate dependent shear viscosity. By comparing the swallowing of these model fluids the specific rheological effects could be distinguished. Sensory analysis of the perceived ease of swallowing was performed by a panel of healthy individuals, and by a group of dysphagic patients. The swallowing of the latter group was also characterized by videofluoroscopy and the transit times in the mouth and pharynx were determined. The hypothesis was confirmed by dysphagic patients who perceived swallowing easier for the elastic model fluids. A sensory panel of healthy individuals could not distinguish differences in swallowing, likely because their swallowing functions well and is an involuntary process. Quantitative videofluoroscopic measurements of swallowing transit times for the dysphagic patients suggested that fluid elasticity contributed to easy and safe swallowing, but the effect was not statistically significant due to the large spread of type of swallowing disorder.

Key words:
Rheology, dysphagia, elastic properties, model fluids, sensory analysis, videofluoroscopy

1 Introduction

The complete chewing and swallowing process is an intricate combination of voluntary and involuntary actions and it involves complex flow geometry as well as a mixture of shear and extensional flow. For healthy individuals it is an integral part of our food processing and a source of pleasure through the experience of textures tastes and flavours. We can influence the process as long as the food is in the mouth, but as soon as the bolus hits the pharyngeal arches we automatically swallow. It is a process we seldom notice unless the swallowing is unpleasant or if it goes wrong. On the other hand, for people suffering from swallowing disorders it is a daily struggle during every meal. Already over 50 years of age 22 % suffer from swallowing disorders and in the age group above 70 years 40 % suffer due to factors such as degenerative diseases, side effects of medication or trauma [1]. As we live longer this is a growing problem, and dysphagia may cause serious states such as pneumonia by the bolus entering the airways and malnutrition due to the difficulties in eating overall [2]. The persons suffering from dysphagia must eat texture adjusted foods, and the oral processing is considerably affected.

By designing the rheological properties of the food, swallow ability can be affected. The National Dysphagia diet describes four levels of liquid consistency defined at 25 °C and a shear rate of 50 s⁻¹ including thin (0.001 to 0.05 Pas), nectar (0.05 – 0.35 Pas), honey (0.35 – 1.75 Pas), and spoon-thick (> 1.75 Pas). Various food thickeners are used to achieve this objective [3]. Low viscosity fluids show more difficulties for swallowing [4] than high viscosity fluids: a viscous bolus is more likely to delay the oral and pharyngeal bolus passage thereby allowing more time for the epiglottis to close [5]. Numerical studies of non-Newtonian and Newtonian fluids has shown that non-Newtonian fluids are...
properties of the model fluids for the current group of patients. Pharyngeal retention is an indication of weak muscles in the pharynx. Residues from swallowed food could stay in the pharynx due to weaker muscles which may cause misdirected swallowing. The physiological health status of the individual patients in this case was the dominant factor in determining the safety of swallowing than the fluids properties of the liquids itself.

4 CONCLUSIONS

Sensory evaluation by dysphagic patients showed that introducing an elastic component over all made the fluid easier to swallow. Healthy individuals could however not distinguish differences in swallowing between the different model fluids, likely because they have normal, involuntary swallowing and instead pick up differences in mouth feel. Quantitative videofluoroscopy measurements of swallowing transit times for the dysphagic patients suggested that fluid elasticity contributed to easy and safe swallowing, but the difference was not statistically significant due to the large spread of type of swallowing disorders among the patients. To our knowledge the oral and pharyngeal transit times for rheological model fluids were measured for the first time for individuals suffering from dysphagia. A Boger fluid compared to its non-elastic Newtonian counterpart has never been tried on dysphagia patients. The extensional properties of the Boger fluid with concentration of 200 ppm xanthan showed relatively small elastic behaviour, especially for small extension rates, explaining the doubtful results of the sensory analysis comparing food products: a mini review, Food Sci. Human Wellness 2 (2013) 173 – 178.

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