5.8

In-vitro characterisation of bolus pressure, velocity and internal shear of non-Newtonian gelled liquid in a tongue-palate simulator

Andrew Redfearn *(University College London), Ben Hanson (University College London)*

Powdered gums used as thickeners produce shear-thinning fluids and lightly-gelled semi-solid materials; these are perceived as slippery. As well as applications in sauces, dressings and desserts, they are increasingly used in the management of disordered swallowing, "dysphagia", often involving reduced tongue strength and/or sensory-motor control. The hypothesis -examined here- is that shear-thinning behaviour can enable bolus transport of fork-able apparently-solid materials without requiring excessive tongue pressure. This study measured intra-bolus flow and tongue-palate pressure using an in-vitro simulation of the compression and oral propulsion of a bolus.

Materials: Thick & Easy Clear containing xanthan and carrageenan (Fresenius-Kabi Ltd) with Evian (Danone Waters) at concentrations designed to match IDDSI texture levels 1-4 respectively.

Methods: 11ml boluses were subjected to a simulated compression wave between a compliant model tongue (E = 132kPa) and rigid flat palate, being transported 70mm in 667ms. Results: Materials matching IDDSI levels 1-4 had flow indices (measured by conventional cone-plate rheometer) from 0.44 to 0.19 -highly non-Newtonian- and consistency indices from 0.50 to 10.61. Particle image velocimetry was used to measure fluid flow: maximum intra-bolus velocity -centrally- typically increased from 34 to 100mm/s as the compression progressed and internal distribution of shear rate varied from 0 centrally to a maximum at the tongue & palate surfaces (from 12 to 28/s). Pressure was mapped at 5 sensor locations showing an increasing gradient from bolus head to tail. Three stages were identified: initial acceleration (rapid pressure rise); transport phase (relatively constant pressure); clearance (pressure increasing as tongue-palate gap reduces and intra-bolus shear rate increases). Transport pressure (0.06 to 1.55kPa) and clearance pressure (0.14 to 4.50kPa) both increased proportionally with consistency index.

Conclusions: The anatomical simulator provided quantitative evidence of how shear-thinning gum-thickened liquids may facilitate swallowing in dysphagia with a solid, fork-able texture (IDDSI Level 4) requiring only 4.50kPa tongue pressure.