SUPPLEMENTARY MATERIAL

Oropharyngeal dysphagia as a risk factor for pneumonia in the elderly

Jordi Almirall, Laia Rofes, Roser Icart, Mateu Serra-Prat, Elisabet Palomera, Viridiana Arreola, Pere Clavé

METHODS

The Volume-Viscosity Swallow Test assesses clinical signs or symptoms of efficacy and safety of deglutition[1]. The test consists of administering boluses of increasing volume (5, 10, and 20 mL) at nectar (295.02±25.91 mPa s), liquid (21.61±0.21 mPa s) and pudding (3682.21±223.20 mPa s) viscosities. Nectar viscosity was obtained by adding 4.5 g of thickener Resource ThickenUp (Nestlé Nutrition, Barcelona, Spain) to mineral water, and pudding viscosity by adding 9 g of the thickener. Boluses were carefully offered to patients with a syringe. Clinical signs of impaired efficacy of swallow are impaired labial seal, oral or pharyngeal residue, and piecemeal deglutition (multiple swallows per bolus); clinical signs of impaired safety during swallow are changes in voice quality (including wet voice), cough or a decrease in oxygen saturation ≥3% measured with a finger pulse-oximeter (Philips Medical Systems, Eindhoven, The Netherlands). The Volume-Viscosity Swallow Test is an effort test designed to protect patients from aspiration by starting with nectar viscosity and increasing volumes in a progression of increasing difficulty. When patients complete the nectar series without symptoms of aspiration, a less safe liquid viscosity series is assessed and finally a safer pudding viscosity series is assessed in the same way. If the patient presents signs of impaired safety, the

series is interrupted. Diagnosis of oropharyngeal dysphagia is established if any of the mentioned signs or symptoms of impaired efficacy or safety is identified in any bolus. Impaired safety of swallow is considered if any of mentioned safety signs is present and impaired efficacy is considered if any of the mentioned clinical signs or symptoms of efficacy is present.

The videofluoroscopic study. All patients with CAP and healthy elderly subjects were imaged while seated, in a lateral projection which included the oral cavity, pharynx, larynx, and cervical esophagus. Videofluoroscopic recordings were obtained by using a Super XT-20 Toshiba Intensifier (Toshiba Medical Systems Europe, Zoetermeer, The Netherlands) and recorded at 25 frames/s using a video camera Panasonic AG DVX-100B (Matsushita Electric Industrial Co, Osaka, Japan). Patients were studied during the deglutition of one series of boluses of 5 mL, 10 mL and 20 mL at nectar viscosity (274.42 ± 13.14 mPa s), one series at liquid viscosity (20.40 ± 0.23 mPa s) and one series at pudding viscosity (3931.23 ± 166.15 mPa s). Liquid viscosity was obtained by mixing 1:1 mineral water and the X-ray contrast Gastrografin (Berlimed SA, Madrid, Spain), nectar viscosity by adding 3.5 g of thickener Resource ThickenUp (Nestlé Nutrition, Barcelona, Spain) to 100 mL of the liquid solution and pudding viscosity by adding 8 g of thickener. Bolus density for liquid was 1.19±0.007 g mL^{-1}, nectar 1.23±0.007 g mL^{-1}, and pudding 1.27±0.001 g mL^{-1}. Boluses were carefully offered to patients with a syringe according to a previously validated protocol.

Signs of impaired safety and efficacy of deglutition during the videofluoroscopic study were identified accordingly to accepted definitions: penetration was defined as the entrance of swallowed material into the laryngeal vestibule and

aspiration as the passage of this material below the vocal cords. The severity of aspirations and penetrations was further characterized according to an 8-point validated scale: patients were considered to have a safe swallow if they scored 1–2 and to have abnormal laryngeal protection if they scored ≥3 on one or more swallows on the penetration-aspiration scale (Figure E1)[2].

Measurements of oropharyngeal swallow response were obtained during 5 mL nectar swallows because all patients swallowed this bolus. Timing of the opening and closing of the velopharyngeal junction, laryngeal vestibule and upper esophageal sphincter were measured, and glossopalatal junction opening was given the time value 0. Vertical and anterior hyoid position was determined in an *xy* coordinate system in each frame: the anterior-inferior corner of C3 was used as the origin, and the vertical axis was defined by a line connecting the anterior inferior corners of C3 and C5. Velocity acquired by the bolus at the upper esophageal sphincter level was calculated through the standard expressions: $v = v_0 + a\,(t-t_0)$ and $s = s_0 + v_0\,(t-t_0) + 1/2\,a\,(t-t_0)^2$, where v is the velocity acquired by the bolus at upper esophageal sphincter level, expressed in m/s; t is the time that bolus takes from glossopalatal junction to upper esophageal sphincter; a is the bolus acceleration achieved at upper esophageal sphincter, expressed in m s^{-2}; s is the distance between the glossopalatal junction and upper esophageal sphincter, in m; and t_0, v_0 and s_0, are time, velocity and distance at time 0 (glossopalatal junction opening), the three parameters are considered 0.

REFERENCES

1. Clave P, Arreola V, Romea M, Medina L, Palomera E, Serra-Prat M. Accuracy of the volume-viscosity swallow test for clinical screening of oropharyngeal dysphagia and aspiration. *Clin Nutr* 2008; 27:806-815.

2. Rosenbek JC, Robbins JA, Roecker EB, Coyle JL, Wood JL. A penetration-aspiration scale. *Dysphagia* 1996; 11:93-98.

Figure S1. The Penetration-Aspiration scale. At the left, picture **A)** shows a safe swallow (level 1), picture **B)** shows a penetration that not reach the vocal folds (levels 2-3), picture **C)** shows a penetration that reach the vocal folds (levels 4-5) and picture **D)** shows an aspiration (levels 6-8). At the right, timelines of a safe swallow (**A**), and delayed swallows, leading to a penetration (white dot, **B**, **C** and **D**) and to an aspiration (red dot, **D**).