Published in final edited form as:

Dysphagia. 2013 September ; 28(3): 464–467. doi:10.1007/s00455-013-9476-7.

Challenges in preparing contrast media for videofluoroscopy

Catriona M. Steele^{1,2,3}, Sonja M. Molfenter^{1,3}, Melanie Péladeau-Pigeon¹, and Shauna Stokely¹

¹Toronto Rehabilitation Institute University Health Network, Toronto, Canada

²Bloorview Research Institute, Holland Bloorview Kids Rehab, Toronto, Canada

³University of Toronto, Toronto, Canada

We would like to congratulate Popa Nita and colleagues [1] for their article exploring the challenges of matching the rheological (i.e. flow) properties of contrast agents used in videofluoroscopy to thickened liquids used in dysphagia management. This article clearly illustrates the complexities of this challenge; however, there are three additional points that we feel would be clinically relevant and important to bring to the attention of the readers of the *Dysphagia* journal:

1. The rheological characteristics of barium preparations need to be understood with respect to how they map to clinical categories of liquid consistency;
2. The concentration of barium in commercially available suspensions affects both its visibility on the radiographic image, and the degree to which the suspension leaves a coating on the pharyngeal mucosa;
3. Mixing barium powder into already-thickened liquids may result in further thickening of the liquid.

We will provide a brief elaboration on each of these points below.

1) Rheological characteristics of readily available barium preparations

Barium products for gastrointestinal imaging come in the form of powders or ready-mixed liquid suspensions. The Varibar® line of products (EZ-EM Canada, Bracco Diagnostics Inc., www.varibar.com) is specially formulated for oropharyngeal imaging, and is offered in thin, nectar, thin-honey, thick-honey and pudding consistencies. Varibar® products may, however, not be universally available to clinicians who perform videofluoroscopy. Regulatory approval has not yet been granted for the clinical use of Varibar® in countries outside the United States.

When access to products like Varibar®, which are tailor made for oropharyngeal examination, it is not uncommon to find clinicians using other imaging products in videofluoroscopy; these products may be mixed in ways that differ from the manufacturer guidelines for intended use. For example, Fink and Ross [2] describe an “ultrathin” barium suspension that they mixed by diluting thin liquid Varibar in a 50:50 ratio with water, in attempts to create a stimulus that represents a true thin liquid more closely.

Corresponding Author: Catriona M. Steele, Toronto Rehabilitation Institute - University Health Network, 550 University Avenue, 12th floor, Toronto, ON, M5G 2A2, Canada, Catriona.steele@uhn.ca, Tel: 416-597-3422 ext. 7603, Fax: 416-597-7173.

Conflicts of Interest:

The authors have no conflicts of interest to disclose.

Polibar (Bracco Diagnostics Inc., Princeton, NJ) is one ready-mixed liquid suspension with a barium concentration of 100% w/v (g/ml), which is quite commonly assumed to be a nectar-thick liquid when it flows out of the bottle. In an article by Cichero, Nicholson and Dodrill [3], the viscosity of room temperature Polibar was reported to be 390 mPa.s at a shear rate of 50 reciprocal seconds, i.e., just above the lower boundary for honey-thick liquids specified in the National Dysphagia Diet (NDD) [4]. The focus of that article was to compare the viscosities of contrast media to infant formulas, and these were found to be markedly different.

Recent rheological testing in our lab has explored the viscosity of liquid E-Z-Paque (EZ-EM Canada, Bracco Diagnostics Inc.), a 60% w/v barium suspension, and a diluted version of E-Z-Paque, mixed with water to achieve a 22% w/v barium suspension. These tests were conducted in triplicate on a TA Instruments AR2000 Advanced Rheometer using cone-plate geometry (40 mm, 2 degree cone) and temperature maintained at 20°C. A shear rate ramp from 0.1–1000 reciprocal seconds was used with 1 minute equilibration periods at each end of the sweep. These tests showed the viscosity of undiluted E-Z-Paque to be approximately 133 mPa.s at 50s⁻¹, (therefore in the nectar-thick range) [4]. When diluted to 22% w/v concentration, the viscosity dropped to the thin range [4] at approximately 17 mPa.s at 50s⁻¹. Therefore, the degree to which a barium product is diluted prior to use will affect its viscosity.

2) Coating properties of liquid barium suspensions

Barium products come in low-density and high-density preparations. The term “density” in these labels refers to the concentration of barium in grams per milliliter of solution. High concentration barium products are also called “double contrast” and are designed to leave a coating on the mucosa of the gastrointestinal tract. E-Z-HD (Bracco Diagnostics Inc., Princeton, NJ) is one example of a high density preparation, which has a 250% w/v concentration when mixed with water according to the manufacturer’s label instructions. Dantas and colleagues have shown that oral and pharyngeal transit times for a 250% w/v solution are significantly longer than for a medium concentration product at 140% w/v [5]. However, the question of where the threshold of mucosal coating begins in terms of barium concentration is not clear. Below are three images taken from a videofluoroscopy of the same healthy young female, swallowing 5 ml volumes of barium liquids with different concentrations. In Figure 1a, a 100% w/v concentration of barium (Liquid Polibar) leaves a clearly visible thin line of residual coating along both the pharyngeal and esophageal mucosa. In Figure 1b, a 60% w/v concentration product (Liquid E-Z-Paque) leaves less visible coating. And in Figure 1c, a 22% w/v concentration prepared by diluting Liquid E-Z-Paque with water leaves no visible coating. It is important for clinicians to be aware that post-swallow residual seen with products of 60% w/v concentration or greater may be partly attributable to the barium rather than pathophysiological.

3) Mixing barium powder into already-thick liquids

The Popa Nita article [1] explores the issue of mixing thickened contrast media for videofluoroscopy by adding thickening powders to liquid contrast media. This is one way of preparing thickened barium stimuli. However, another approach is to begin with thickened liquids (either commercially or kitchen prepared) and to mix barium powders (such as E-Z-HD) into these already-thickened liquids. This can be a pragmatic approach, using the very same thickened liquids that are provided to patients from a hospital kitchen and making a barium version of these liquids. However, it is a mistake to assume that the addition of barium to these liquids does not alter their viscosity. Figures 2 and 3 illustrate this scenario with two different commercially pre-thickened liquids, for which rheological testing was

conducted at a chilled temperature of 10°C according to the same procedures described above. In Figure 2a, the viscosity of a commercially pre-thickened apple juice (Sysco Imperial Thickened Juices, Lyons, Fresno, CA) is shown as approximately 400 mPa.s at a shear rate of 50s⁻¹, therefore close to the NDD lower boundary for honey-thick liquids. However, in Figure 2b, the same product was mixed with E-Z-HD powder (102 grams of 98% w/w powder per 250 ml cup of solution) in order to achieve a 40% w/v barium concentration, similar to the concentration of the Varibar barium product line. Here it is shown that the viscosity of the resulting product is approximately 800 mPa.s at 50s⁻¹; although this viscosity still technically falls within the NDD boundaries of honey-thick consistency, it is approximately twice as thick as the non-barium product. Figures 3a and 3b illustrate the same phenomenon with Resource® nectar-thick apple juice (Nestlé Health Science, North York, ON, Canada), albeit not to the same degree. Discussion of this phenomenon with rheologists suggests that the starch molecules inside these commercially thickened liquids are probably forming complexes around the barium molecules, leading to further thickening. Other thickening agents, such as those using xanthan gum, may not be as susceptible to this chemical reaction. Furthermore, in order to get good dispersion of barium throughout a thickened liquid, or of thickener throughout a barium suspension, magnetic stirring over a prolonged time frame (e.g., 30 minutes) may be needed.

Evidence of further thickening following the addition of barium to thickened liquids is troubling because it shows that the barium thickened liquid can no longer be considered representative of the viscosity of the thickened liquid. Clinical decisions that are made based on the observation of swallowing with the barium thickened liquid may be inaccurate in two ways: 1) the additional thickening of the barium product may have therapeutic value for limiting penetration-aspiration and may mask a safety risk that exists with the non-barium thickened liquid; 2) the thicker barium product may be more prone to leave residue after the swallow [6], masking adequate or nonimpaired bolus clearance with the non-barium thickened liquid. At this time, we are unaware of any recipes for barium preparation with thickened liquids that satisfactorily overcome these concerns. We recommend that clinicians choose a desired concentration for their barium stimuli and develop or follow recipes to achieve this concentration whenever they are mixing barium for use in videofluoroscopy. However, clinicians should be cognizant of the fact that their stimuli may not be truly representative of nonbarium liquids. Further research will be needed to develop and test recipes for off-label barium preparation.

In conclusion, we would like to echo the sentiments of the Popa Nita et al. article [1], in emphasizing that contrast media for videofluoroscopy need to be chosen and prepared with care. Preparing contrast media that match non-test products is not a simple or straightforward matter. Clinicians need to consider the limitations of this challenging situation when conducting and interpreting videofluoroscopies.

Acknowledgments

Funding support for the work described in this letter to the editor was provided through an NSERC Create Care Award to the 2nd author (SM). Additional funding support was received through a Canadian Institutes of Health Research New Investigator award and an NIDCD RO1 grant to the first author (CMS) and from the Toronto Rehabilitation Institute – University Health Network, which receives funding under the Provincial Rehabilitation Research Program from the Ministry of Health and Long-Term Care in Ontario. The views expressed do not necessarily reflect those of the Ministry.

The authors gratefully acknowledge the assistance of Sarah Hori, Clemence Tsang, Rossini Yue and Tasnim Shariff with data collection, and Dr. David James for use of rheological testing equipment.

References

1. Popa Nita S, Murith M, Chisholm H, Engmann J. Matching the Rheological Properties of Videofluoroscopic Contrast Agents and Thickened Liquid Prescriptions. *Dysphagia*. 2013
2. Fink TA, Ross JB. Are we testing a true thin liquid? *Dysphagia*. 2009; 24:285–289. [PubMed: 19234743]
3. Cichero J, Nicholson T, Dodrill P. Liquid Barium is not Representative of Infant Formula: Characterisation of Rheological and Material Properties. *Dysphagia*. 2010
4. National Dysphagia Diet Task Force. ADA: National Dysphagia Diet: Standardization for Optimal Care. Chicago, IL: Faulhaber, D; 2002.
5. Dantas RO, Dodds WJ, Massey BT, Kern MK. The effect of high- vs low-density barium preparations on the quantitative features of swallowing. *AJR American Journal of Roentgenology*. 1989; 153:1191–1195. [PubMed: 2816631]
6. Hind J, Divyak E, Zielinski J, Taylor A, Hartman M, Gangnon R, Robbins J. Comparison of standardized bariums with varying rheological parameters on swallowing kinematics in males. *Journal of Rehabilitation Research and Development*. 2012; 49(9):1399–1404. [PubMed: 23408220]

Figure 1a.

Figure 1b.

Figure 1c.

Figure 1.

Figure 1a. Residual coating following a 5cc swallow of 100% w/v liquid barium suspension

Figure 1b. Residual coating following a 5cc swallow of 60% w/v liquid barium suspension

Figure 1c. Residual coating following a 5cc swallow of 22% w/v liquid barium suspension

Figure 2a.

Figure 2b.

Figure 2.

Figure 2a. Rheogram showing the viscosity of a commercially available thickened apple juice (Sysco brand).

Figure 2b. Rheogram showing the viscosity of a commercially available thickened apple juice (Sysco brand) mixed with E-Z-HD barium powder for a 40% w/v barium concentration.

Figure 3a.

Figure 3b.

Figure 3.

Figure 3a. Rheogram showing the viscosity of a commercially available thickened apple juice (Nestlé Resource® Nectar-thick Apple Juice).

Figure 3b. Rheogram showing the viscosity of a commercially available thickened apple juice (Nestlé Resource® Nectar-thick Apple Juice) mixed with E-Z-HD barium powder for a 40% w/v barium concentration.