In vitro comparisons of different mixtures of sodium tetradeyl sulfate-based sclerotherapy foam

Poster No.: C-2279
Congress: ECR 2014
Type: Scientific Exhibit
Authors: H. Ninalowo¹, J. Koizumi², B. Endale¹, B. Janne d'Othee¹;
¹Baltimore, MD/US, ²Isehara-City, Kanagawa-pref./JP
Keywords: Varices, Blood, Arteriovenous malformations, Venous access, Sclerosis, Embolisation, Percutaneous, Experimental, Catheter venography, Veins / Vena cava, Interventional vascular, Cardiovascular system
DOI: 10.1594/ecr2014/C-2279

Any information contained in this pdf file is automatically generated from digital material submitted to EPOS by third parties in the form of scientific presentations. References to any names, marks, products, or services of third parties or hypertext links to third-party sites or information are provided solely as a convenience to you and do not in any way constitute or imply ECR's endorsement, sponsorship or recommendation of the third party, information, product or service. ECR is not responsible for the content of these pages and does not make any representations regarding the content or accuracy of material in this file.

As per copyright regulations, any unauthorised use of the material or parts thereof as well as commercial reproduction or multiple distribution by any traditional or electronically based reproduction/publication method ist strictly prohibited.

You agree to defend, indemnify, and hold ECR harmless from and against any and all claims, damages, costs, and expenses, including attorneys' fees, arising from or related to your use of these pages.

Please note: Links to movies, ppt slideshows and any other multimedia files are not available in the pdf version of presentations.

www.myESR.org
Aims and objectives

Sclerotherapy is an important technique to treat (a) varices in multiple territories and (b) vascular malformations (both venous and lymphatic).

Foam sclerotherapy has largely supplanted liquid sclerotherapy thanks to the foam's abilities (1) to reduce the dose of sclerosing agent injected (safety) and (2) to visualize the sclerosant on real-time ultrasonography (imaging)\textsuperscript{(1,2)}.

Creation of the foam is made by mixing a liquid sclerosing agent with a gas, typically either air or carbon dioxide (CO\textsubscript{2}).

Clinical efficacy of the foam to occlude permanently target vessels is postulated to rely on displacement of the blood in the vascular lumen and prolonged contact between the foam and the venous endothelium. A longer contact time is believed to be critical to ensure therapeutic efficacy and long-term venous occlusion without recurrence\textsuperscript{(3)}.

However, the foam returns inevitably to a liquid phase after a given amount of time ("defervescence" phenomenon), which may vary depending of a variety of factors.

There is limited literature on the topic, with only one extensive in vitro experimental study to date\textsuperscript{(4)}. The present in vitro experiments is aimed at characterizing the factors that affect foam durability using a novel and systematic methodology.
Methods and materials

**Foam creation**

Foam was created by the Tessari method using various mixtures of fluid sclerosant and gas. The Tessari method \(^{(1)}\), the most commonly reported technique to make foam, consists of rapid back-and-forth movements of the plungers of two syringes connected by a three-way stopcock. The same types of syringes and stopcock were used throughout all experiments.

The fluid sclerosant agent consisted of sodium tetradecyl sulfate (Sotradecol\textsuperscript{TM}, AngioDynamics, Inc., Queensbury, NY, USA). The gas consisted of either air or CO\textsubscript{2}.

**Data collection**

The evolution over time of the height of the foam column in the vertical syringe (outcome variable) was videorecorded (Fig. 1 on page 4) and measured at regular time intervals from initial creation to near-complete dissipation, yielding time-defervescence curves for each experiment.

Experiments were performed in parallel for air and CO\textsubscript{2}. Each pair of experiment was repeated at least three times and average values were calculated.

**Data analysis**

Each defervescence curve (outcome) was analyzed by using two parameters that describe its evolution over time: half-life (t\textsubscript{1/2}) and area under the curve (AUC).

**Five predictor variables** were studied separately:

1. number of prior foam preparations with a given STS solution,
2. number of pumping iterations during foam creation,
3. fluid-gas ratio,
4. gas type (air versus CO\textsubscript{2}), and
5. STS concentration.
**Fig. 1:** Video recording of foam defervescence over time: the foam was made and is contained in the vertical syringes (foam with CO2 on the left and with air on the right).

© Radiology, Division of Vascular & Interventional Radiology, University of Maryland School of Medicine, University of Maryland Medical Center - Baltimore/US
Results

The results for the five predictor variables investigated showed the following:

1. **Re-using the sclerosant fluid** did not affect foam durability, which remained similar regardless of how many times a Sotradecol\(^\text{TM}\) solution had been used before.
2. The **number of pumping iterations** (from 2-10 cycles) did not affect foam durability either.
3. The **fluid-gas ratio** did affect the foam half-life and the area under its defervescence curve. A fluid-gas ratio of 1:4 is the optimal compromise between initial foam volume (larger at higher ratios) and foam durability (lesser at higher ratios).
4. **Gas type**: Air-based foams showed markedly longer durability than CO\(_2\)-based foams, in terms of both half-life and area under the defervescence curve (Fig. 2 on page 6). In the optimal case scenario (i.e., at a fluid-gas ratio of 1:4), air-based foam lasted 1.8-2 times longer than CO\(_2\)-foam (mean half-life +/- SD 3.0 +/- 1.6 times longer, area under the curve 2.6 +/- 1.4 times larger) (Fig. 3 on page 6).
5. Interestingly, foam stability increased at lower concentrations of the liquid sclerosant, most notable from a change from 3% to 1.5% STS with no further increase in foam durability at concentrations lower than 1.5% (Fig. 4 on page 7).

Our last finding above (number 5) contradicts most prior reports, which had suggested that foams made with higher concentrations of sclerosing agent last longer \(^{2-6}\). Some of these studies \(^{2-3}\) were preliminary analyses and did not investigate the issue systematically. Two other studies \(^{5-6}\) measured the half-life indirectly by focusing on the time taken to reconstitute half of the height of the liquid phase in a syringe rather than assessing directly the height of the foam column. Also, these two studies and another one \(^{4}\) focused on the foam half-life and did not investigate the area under the curve (AUC) of the time "defervescence" graph.
Fig. 2: Evolution of average height of foam column (Y axis) over time (X axis) for various concentrations of sodium tetradecyl sulfate (STS) and either air or CO2 as the gas of choice.

© Radiology, Division of Vascular & Interventional Radiology, University of Maryland School of Medicine, University of Maryland Medical Center - Baltimore/US
**Fig. 3:** Defervescence curve of the foam in the vertical syringe: height of the foam column in the syringe (Y axis) is plotted against time (X axis). Air-based foam (red curve) returns much slower to liquid phase than CO2-based foam (blue curve).

© Radiology, Division of Vascular & Interventional Radiology, University of Maryland School of Medicine, University of Maryland Medical Center - Baltimore/US
Fig. 4: Concentration of sodium tetradecyl sulfate (STS; X axis) plotted against the area under the curve (AUC; Y axis) of the foam defervescence. The area under the curve is relatively similar at STS concentrations between 0.1875% and 1.5%, but decreases for high (3%) STS concentration; the phenomenon is more apparent with air than with CO2.

© Radiology, Division of Vascular & Interventional Radiology, University of Maryland School of Medicine, University of Maryland Medical Center - Baltimore/US
Conclusion

1. Best foam stability was confirmed with air at a 1:4 fluid-gas ratio.
2. Foam is markedly more durable when made with air than when using CO\textsubscript{2}.
3. Foam durability increased with decreasing sclerosant concentration from 3% to 1.5% STS (contrarily to prior reports), then remaining relatively stable between 1.5% and 0.1875%.
Personal information

http://medschool.umaryland.edu/facultyresearchprofile/viewprofile.aspx?id=21541
References


