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A preliminary study on sclerofoam morphology.

Étude préliminaire de la morphologie des mousses sclérosantes.

Cosmi F.[1], Biasi G.[2]

Summary

An original experimental approach has been proposed, in which micro-tomography and morphological techniques have been successfully used to investigate the possibility and the significance of a morphology characterization of sclerofoams.

Several sclerofoams samples were prepared in different conditions and different concentrations of Polidocanol and immediately quickly frozen in liquid N_2 in order to avoid macro-crystals formation. Then, they were subjected to micro-tomography at the Tomolab facility of Elettra, Trieste.

The 3D reconstructions of the internal structures of the foams were successively analyzed and morphological parameters such as number, dimensions and degree of isotropy of the bubble structures obtained could be assessed.

The preliminary results obtained so far confirm that micro-tomography is a technique that can be successfully used to characterized the types of sclerofoam obtained with the different methods currently in use.

Keywords: *sclerofoam, micro-CT, morphology, Quant3D, Pore3D.*

Résumé

Cette étude repose sur une approche expérimentale originale, utilisant des micro-tomographies et des techniques morphologiques ont pu être utilisées avec succès pour étudier la survenue et la signification de la caractérisation morphologique des mousses sclérosantes.
Plusieurs échantillons de mousses sclérosantes ont été préparés dans différentes conditions avec différentes concentrations de polidocanol. Elles ont été immédiatement congelées rapidement dans l'azote liquide afin d'éviter la formation de macro-cristaux. Ensuite, elles ont été soumises à la micro-tomographie grâce au Tomolab d'Elettra, Trieste.
Les reconstructions 3D de la structure interne des bulles de mousse ont été successivement analysées et les paramètres morphologiques des structures obtenues ont pu être évalués : tels que le nombre, les dimensions et le degré d'isotropie de la bulle.
Les résultats préliminaires obtenus jusqu'à présent confirment que la micro-tomographie est une technique qui peut être utilisée avec succès pour caractériser les types de mousses sclérosantes obtenues pouvaient être évalués obtenus avec les différentes méthodes actuellement en usage.

Mots-clés: mousses sclérosantes, micro-CT, morphologie, Quant3D, Pore3D.

Introduction

In the last years, foam sclerotherapy has been used widely in the treatment of the chronic venous insufficiency because it has permitted the cure of medium-small varicose veins but most importantly it has allowed the cure of the saphenous trunks.

UGFS (Ultrasound Guided Foam Sclerotherapy) is nowadays considered to be a valid substitution for the traditional surgery and for the other endovascular procedures (i.e. EVLA and radiofrequency) used in the treatment of the small and great saphenous vein.

During these last years, many authors have proposed different techniques to produce the foam and different concentration of the sclerosant drug to use depending on the diameter of the vein treated [1, 2, 3, 4, 5, 6, 7]. The method that is used more frequently is Tessari's [1].

This involves a 3 way connector and a mixture of sclerosant liquid (sodium tetradecyl sulfate 1-3% or polidocanol 0.25-0.50-1-3%) and gas (air) in the volumes proportion of 1:4. Progressively, the requirements for the fabrication of an effective and safe foam, have become more defined instead of spherical [8] bubbles.

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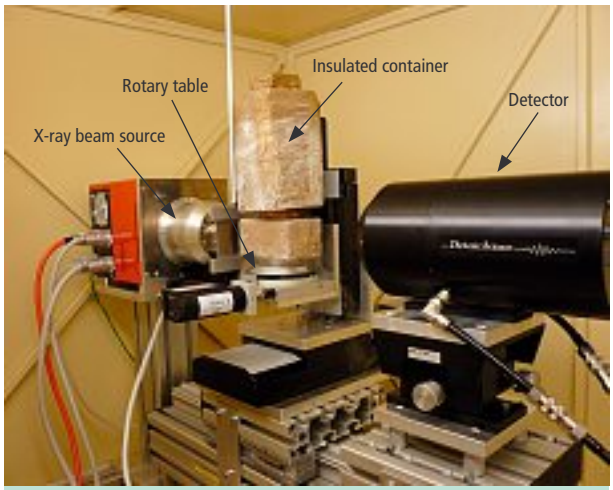

FIGURE 1 : The acquisition set-up at the Tomolab facility of Elettra (Trieste, Italy).

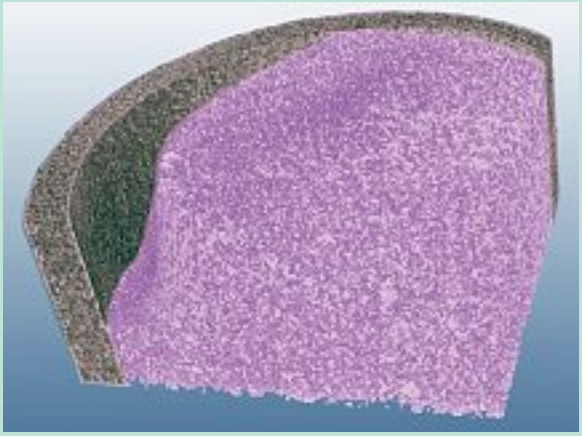

FIGURE 2 : A portion of the 3D reconstruction of a polidocanol foam (the external part of the tube is also visible).

There have been several attempts to standardize the foam using different devices (Turbofoam, Sterivein).

Furthermore, different techniques for the foam injection and materials have been described by various authors.

The aim of this work is to investigate the possibility and the significance of a morphology characterization of sclerofoams obtained under different preparation conditions.

Materials and Method

In this study, six sclerofoams samples were prepared in laboratory. According to the Tessari's method [13], we obtained the foam by mixing 20 or 50 times air and polidocanol drug (3% and 0.5% concentration) using two syringes and a three-way connector. Each foam was then injected in a Eppendorf tube using pipes of different dimensions (C1: 1.3 × 45 mm and C2: 0.3 × 13 mm) and immediately quick-frozen in liquid N_2 to avoid macro-crystals formation while preserving the foam structure during the measurements.

A non-destructive definition of the frozen sample three-dimensional internal structure was obtained by X-ray micro-Computed Tomography. The set-up used at the Tomolab facility of Elettra (Trieste, Italy) achieves a spatial resolution of 10 micron.

The sample, contained in a insulated box, is placed on a rotating table and several projections are acquired at different angles over 180 degrees **(Figure 1)**.

The 3D reconstructions **(Figure 2)** of the foams structures were analyzed and several morphological parameters such as number, dimensions and degree of isotropy of the bubble structures were computed [14, 15, 16].

Experimental Results

Differences can be easily observed in the structures obtained with different foam preparation methods, for example by examining the samples tomographic sections shown in **Figure 3**.

The morphological analyses were conducted on a 2003 voxel volume extracted from the central portion of the samples.

A quantitative characterization of the different foam microstructures can be attained by computing the histograms of the bubbles volume and of the bubbles wall thickness (obtained by Pore3D [4] and by Quant3D [5] software respectively), as shown in **Figure 4** and **Figure 5**.

Conclusions

An original experimental approach has been proposed, in which micro-tomography and morphological techniques have been successfully used to characterized the sclerofoams.

To our knowledge, this is also the first attempt to monitor sclerofoams for applied research purposes.

In this first step of the research, we were able to detect differences among the samples prepared in different conditions.

Nevertheless, in order to obtain quantitative results of clinical significance, a larger number of experimental observations is required and further work has already been planned.

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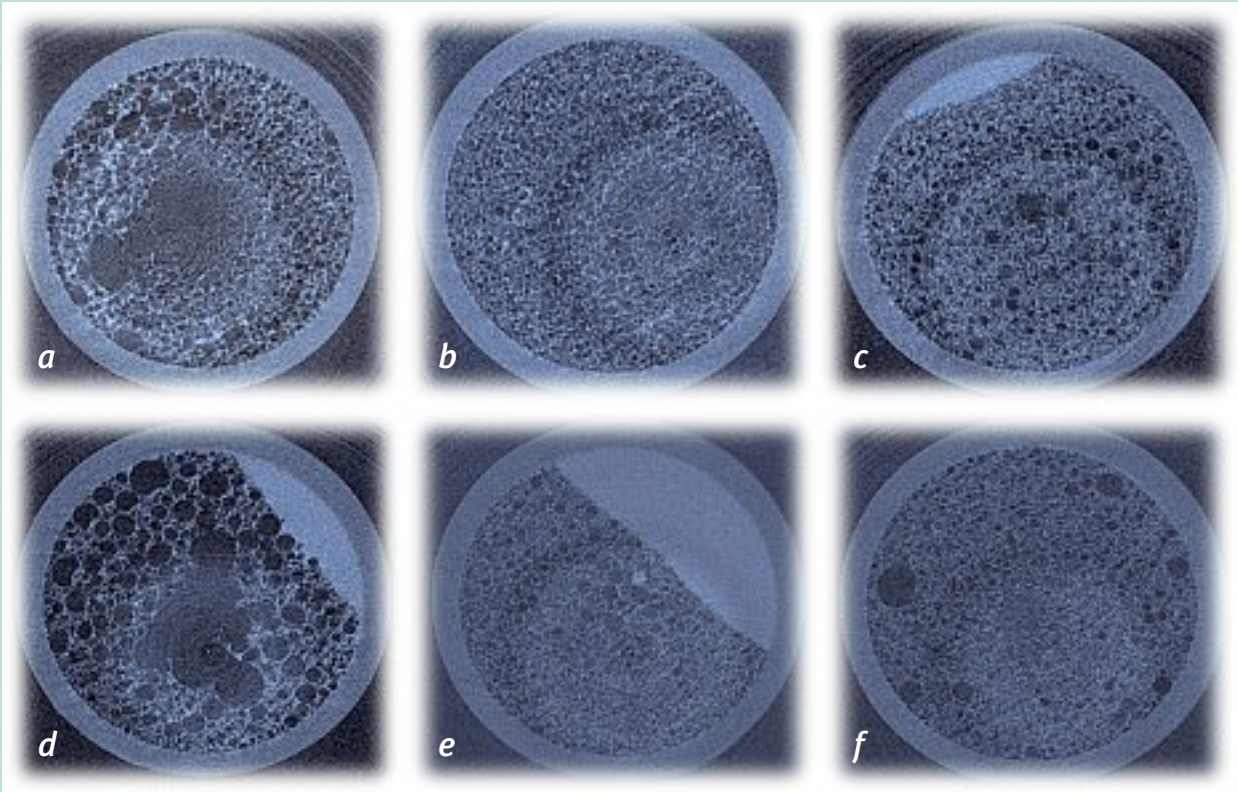

FIGURE 3 : Different foam structures obtained by varying the preparation parameters: (a) 3% 20 x C1; (b) 3% 20 x C1; (c) 0.5% 20 x C1; (d) 0.5% 50 x C1; (e) 0.5% 20 x C2; (f) 0.5% 50 x C2.

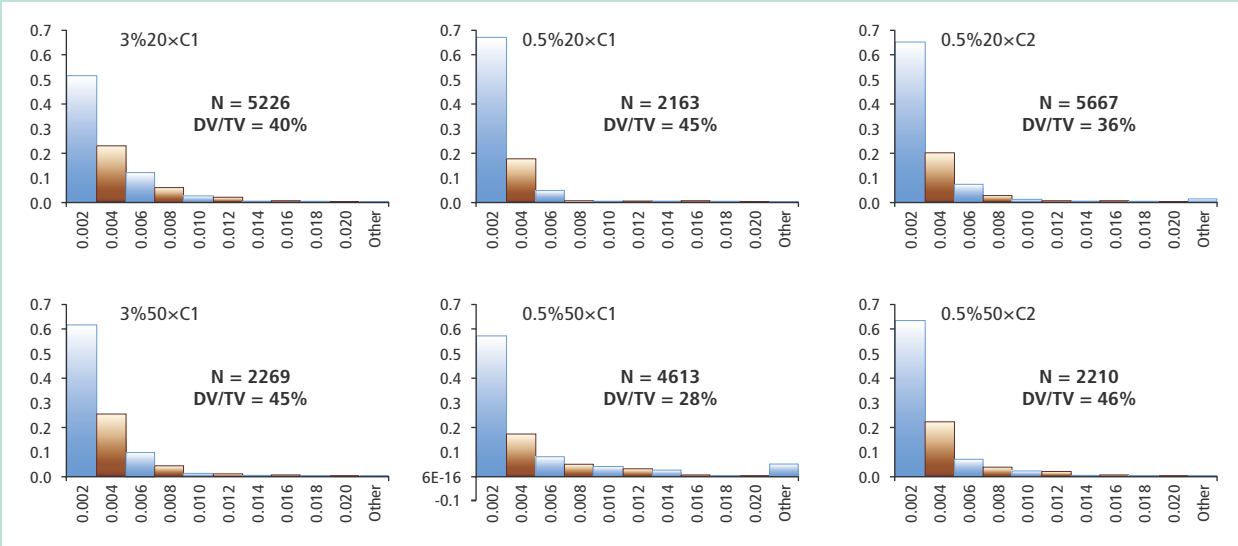

FIGURE 4 : Histograms of the bubbles volume.

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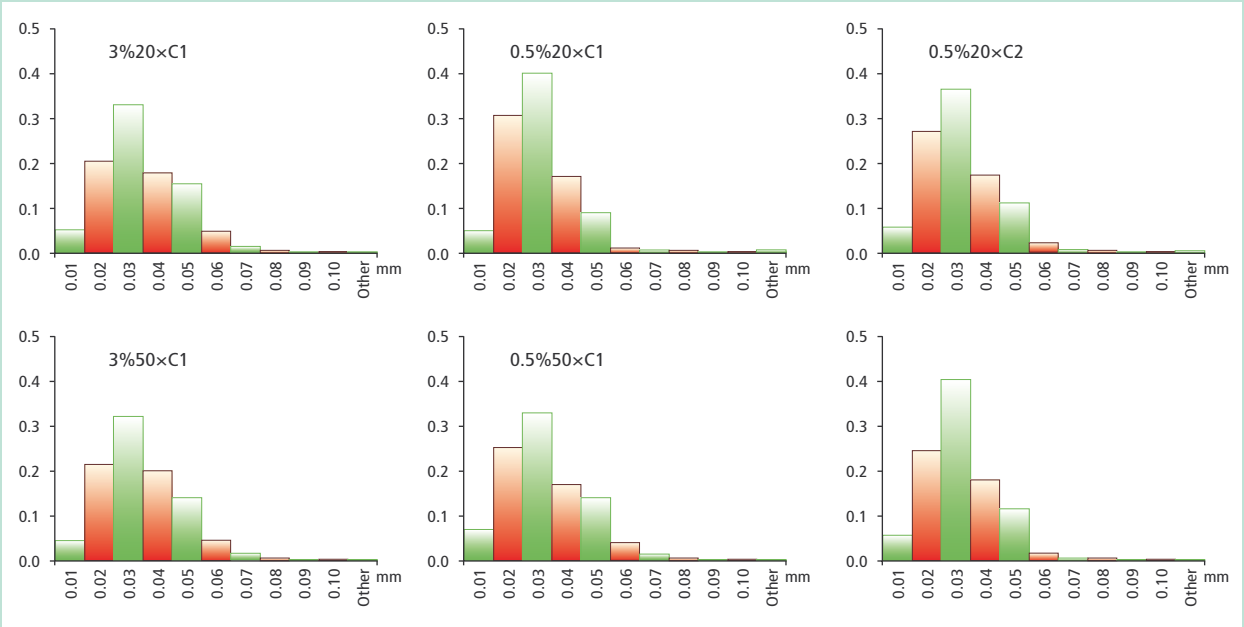

FIGURE 5 : Histograms of the bubbles wall thickness.

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