Stability of Foam in Sclerotherapy: Differences between Sodium Tetradecyl Sulfate and Polidocanol and the Type of Connector Used in the Double-Syringe System Technique

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BACKGROUND. **Foam sclerotherapy is an increasingly popular modality in the treatment of varicose veins. Worldwide, the most popular agents used are sodium tetradecyl sulfate (STS) and polidocanol (POL). The double-syringe system technique to make foam out of a sclerosing solution and air has received wide attention for its ease and reproducibility. This study examined the possibility that the relative silicone content of various disposable connectors may affect overall foam stability. We also evaluated the differences in the stability of foam between STS and POL.**

MATERIALS AND METHODS. **In the first part of the study, one nondisposable stainless steel connector and five disposable plastic connectors were used to create foam from STS 0.50% and air. The procedure was then repeated to produce foam from POL 0.50% and air from each of the six different connector types. As a measure of foam stability, once foam was created with each type of connector, the time required for half of the original volume of sclerosing solution to settle was recorded. In the second part of the study, foam was created with a nondisposable stainless steel connector only and various concentrations of STS and POL. Foam stability was then measured for these different concentrations of sclerosants.**

RESULTS. **The time for sclerosing solution to settle to half of its initial volume was found to vary according to the specific sclerosant and concentration used, with no statistically significant variation based on connector type.**

CONCLUSIONS. **The type of connector used in the double-syringe system technique to produce foam for sclerotherapy is not a factor in foam stability. Sclerosing solutions differ in their foaming stability.**

JAGGI RAO, MD, AND MITCHEL P. GOLDMAN, MD, HAVE INDICATED NO SIGNIFICANT INTEREST WITH COMMERCIAL SUPPORTERS.

THE USE of foam sclerosing solutions is a popular modality in the treatment of large and small varicose veins. Foam has the advantage of creating a homogeneous distribution of the sclerosing solution, with decreased side effects, such as skin necrosis.[1]

The most commonly used system to produce foam today is the double-syringe system (DSS) technique.[2] Here, two syringes are connected by a two- or three-way stopcock, with the sclerosing solution in one syringe and air in the second syringe drawn back and forth by pump movements.

The longer the sclerosant+air mixture remains as a foam in vivo, the higher the likelihood that the foam will travel into other nontargeted veins. Foam half-life, or the time for a volume of foam to be reduced to half of its original volume, is one measure of foam stability. Prolongation of half-life is directly related to increasing the stability of the bubbles that comprise the foam. Bubble stability is dependent on several factors, including the specific sclerosant and concentration used to create the foam, the air-to-sclerosant ratio, the average diameter of the bubbles within the foam, and any additional ingredients used in its preparation. Of interest is the hypothesis that silicone present in disposable equipment such as syringes, infusion tubes, and connectors as a lubricant can reduce foam stability. It has been postulated that this effect is caused by the destruction by silicone of the foam lamellae.

In this study, various connectors were used to measure the half-life of foam created by the DSS technique. With the assumption that each connector would vary from one another in their silicone content, it was hypothesized that half-lives would vary depending on the connector used, with the longest half-life attributed to the connector with the lowest relative amount of silicone.

The second part of this study examined the effect of sclerosant type and concentration on foam stability.

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By keeping the connector type constant, foam was created by two common types of sclerosing agents, with half-life measured for each of a variety of different sclerosant concentrations.

Materials and Methods

Part 1

In the first part of the study, foam half-life was measured for six different connectors using sodium tetradecyl sulfate (STS) 0.50% (STD Pharmaceuticals, Hereford, England) and then repeated using polidocanol (POL) 0.50% (Kreussler, Wiesbaden, Germany). These two agents were selected because they are the most popular foam sclerosants used worldwide.[3]

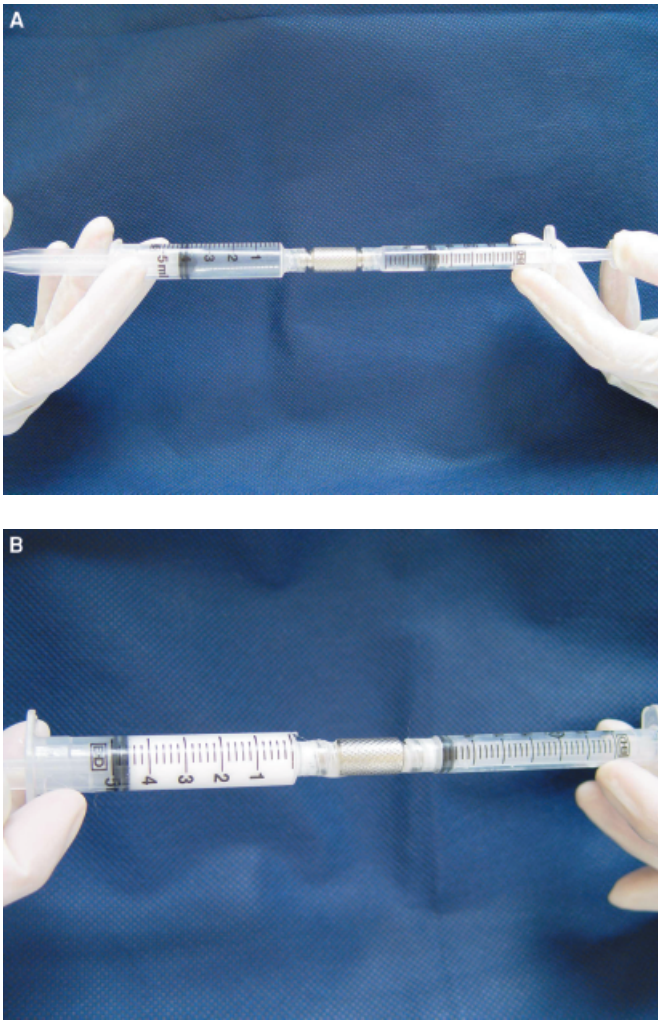

Figure 1. Creation of foam. (A) A 5 mL syringe containing 4 mL of air is connected to a Stainless Steel Two-Way connector on one end, with a 3 mL syringe containing 1.0 mL sclerosant on the other end. (B) Homogeneous white foam created at the end of 10 pumps performed in a to-and-fro motion by pushing the two syringes.

Foam Creation

The following standardized technique was employed throughout the study to create foam and determine exact foam half-lives. A sterile 5 mL syringe with 4 mL of predrawn air was attached to one end of a Stainless Steel 2-Way connector (Byron Medical, Tucson, AZ, USA). A sterile 3 mL syringe was then used to draw up 1.0 mL of STS or POL 0.50% sclerosant and was connected to the other end of the Stainless Steel 2-Way connector (Figure 1A). Using the DSS technique, the 5 mL syringe was pushed to empty the 4 mL of air as much as possible through the connector to the 3 mL syringe with the sclerosant. This action was counted as one pump. Immediately thereafter, the air+sclerosant mixture in the 3 mL syringe was emptied through the connector to the 4 mL syringe. This action was counted as two pumps. Subsequently, the to-and-fro cycle was repeated for a total of 10 pumps. At completion of the 10 pumps, a homogeneous white foam was created and filled the 5 mL syringe (Figure 1B).

Measuring Foam Stability

With the foam filling the 5 mL syringe, the 5 mL syringe was then disconnected from the stainless steel two-way connector and placed exactly vertical with the rubber stopcock of the syringe on the bottom. The timer was started. Over the course of time, as the foam degenerated back into its constituents, the sclerosing solution was found to gradually re-form at the bottom of the syringe. When the bottom of the solution's meniscus attained a volume of exactly 0.5 mL (half of the original sclerosing volume of 1.0 mL), as measured by the graduations on the side of the syringe, the timer was stopped and the time was recorded in seconds (Figure 2).

This process was repeated for the remaining five disposable connectors, using POL and STS 0.50%. Two sets of recordings were obtained and averaged for each connector used. All recordings were performed at an ambient room temperature of 20°C.

Part 2

In the second part of the study, half-life was measured for foam created using only the stainless steel two-way connector, with each of the following concentrations of STS: 0.25%, 0.50% (performed in part 1), and 1.0%. This procedure was repeated using the following concentrations of POL: 0.25%, 0.50% (performed in part 1), and 1.0%. A standardized technique to create foam and measure half-life was employed as outlined in part 1. Two sets of recordings were obtained for each measurement and averaged. All recordings were performed at an ambient room temperature of 20°C.

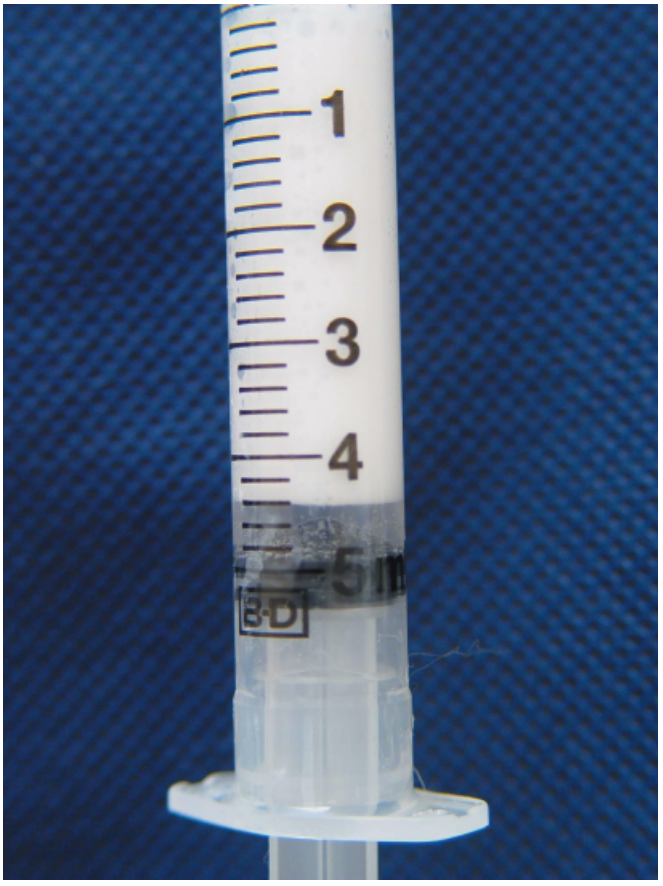

Figure 2. Measuring foam stability. With the timer started at the creation of the foam, the timer was stopped when the bottom of the fluid meniscus reached a level of 0.5 mL of solution (exactly half of the original 1.0 mL).

Results

Part 1

The results are summarized in Tables 1 and 2. After two sets of recordings for each connector used in each of the two arms of the study, it was found that the time required for foam to destabilize was approximately the same for the specific sclerosant and concentration used and not the type of connector used. For STS 0.50%, the average time recorded was 98.1 seconds (range 96–100 seconds), and for POL 0.50%, the average time recorded was 105.3 seconds (range 103–108 seconds).

Part 2

The results are summarized in Tables 3 and 4. After two sets of recordings for each trial, it was found that

Table 2. Times for 0.5 mL of Polidocanol to Settle from a Foam Mixture Containing 1.0 mL of Polidocanol 0.50%

Connector Name	*Time 1, s*	*Time 2, s*	*Average Time, s*
Stainless Steel 2-Way	106	107	106.5
B/Braun 2-Way	107	105	106.0
Kendall 3-Way	107	107	107.0
Discofix 3-Way	104	107	105.5
Vycon 3-Way	104	108	106.0
Connecta Plus 3-Way	103	105	104.0

Average time = 105.8 seconds.

Table 3. Times for 0.5 mL of Sodium Tetradecyl Sulfate to Settle from a Foam Mixture Containing 1.0 mL of Various Sodium Tetradecyl Sulfate Concentrations*

Sclerosing Agent	*Time 1, s*	*Time 2, s*	*Average Time, s*
STS 0.25%	94	96	95.0
STS 0.50%	100	98	99
STS 1.0%	92	91	91.5

STS = sodium tetradecyl sulfate.
*A Stainless Steel Two-Way connector was used in each trial to create foam.

Table 4. Times for 0.5 mL of Polidocanol to Settle from a Foam Mixture Containing 1.0 mL of Various Polidocanol Concentrations*

Sclerosing Agent	*Time 1, s*	*Time 2, s*	*Average Time, s*
POL 0.25%	82	86	84.0
POL 0.50%	106	107	106.5
POL 1.0%	108	112	110.0

POL = polidocanol.
*A Stainless Steel Two-Way connector was used in each trial to create foam.

Table 1. Times for 0.5 mL of Sodium Tetradecyl Sulfate to Settle from a Foam Mixture Containing 1.0 mL of Sodium Tetradecyl Sulfate 0.50%

Connector Name	*Time 1, s*	*Time 2, s*	*Average Time, s*
Stainless Steel 2-Way (Byron Medical, Tucson, AZ, USA)	100	98	99.0
B/Braun 2-Way (B.Braun Medical Inc., Bethlehem, PA, USA)	98	98	98.0
Kendall 3-Way (Kendall Solution Plus 3-Way Stopcock, The Kendall Company, Mansfield, MA, USA)	100	97	98.5
Discofix 3-Way (B.Braun Medical Inc., Bethlehem, PA, USA)	97	98	97.5
Vygon 3-Way (Vygon Corp., East Rutherford, NY, USA)	97	100	98.5
Connecta Plus 3-Way (Datex-Ohmeda Division Instrumentation Corp., Helsinki, Finland)	96	98	97.0

Average time = 98.1 seconds.

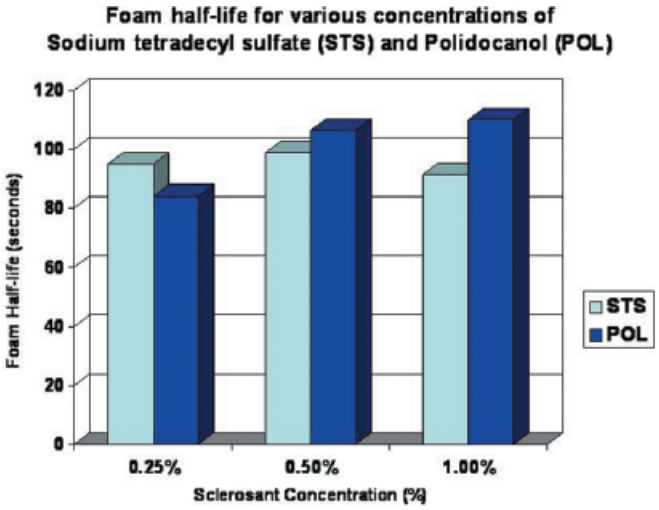

Figure 3. Foam half-life chart.

the time for foam to destabilize was unique to each sclerosant and concentration used. This result is represented graphically in Figure 3. Of interest, the trend for STS and POL is not similar (ie, the shapes of both curves are different), with STS the most stable at 0.50% and POL showing the greatest stability at 1.0%.

Discussion

In this study, two common foam sclerosing agents, STS and POL, were used with various connectors to demonstrate that the type of connector used does not play a factor in foam stability when using the DSS technique. The Stainless Steel 2-Way connector was used as a control because it does not contain silicone, yet the difference in foam dissolution times with this connector compared with others was not statistically significant. Likewise, the Connecta Plus 3-Way connector (Kendall Solution Plus 3-Way Stopcock, The Kendall Company, Mansfield, MA, USA), which has the largest surface area and likely the highest amount of silicone compared with the other connectors, also had time variations that were not statistically significant.

Bubble stability and, hence, foam half-life are not diminished by the type of connector used in the DSS technique described in this study. It is possible that the amount of silicone in the disposable connectors was negligible. Alternatively, the cohesive forces of silicone molecules to the disposable connectors may have been stronger than the adhesive forces between the foam bubbles and the silicone. Finally, the amount of silicone in the 3 mL and 5 mL syringes could be the most important factor. Therefore, an additional study testing a variety of syringes may be necessary. Unfortunately, it is necessary for a syringe plunger to flow easily, necessitating the use of silicone as a lubricant. In an era in which standardization of materials and technique is paramount to achieving inter- and intrauser reproducibility in sclerotherapy, this study is important in illustrating that connector type is one less factor to be accounted for.

Perhaps the most important discovery in this study is the differences in stability between the two tested sclerosing agents and the fact that foam stability is concentration dependent. Whether this has any measurable in vivo effect on either clinical efficacy or adverse effects between the two sclerosing solution awaits further study, which is presently under way.

References

1. Mayer H, Brücke H. Angiologie—zur Ätiologie und Behandlung der Varizen der unteren Extremitäten. Chir Prax 1957;4:521–8.
2. Ouvry P, Barrellier MT, Escalard JM, et al. Sclerotherapy of the long saphenous vein with foam of Lauromacrogol. A prospective duplex controlled randomized study. Protocol and first result. Int Angiol 2001;20 Suppl 1:343–7.
3. Goldman MP. Treatment of varicose and telangiectatic leg veins: double-blind prospective comparative trial between aethoxysklerol and sotradecol. Dermatol Surg 2002;28:52–5.