

Sodium Tetradecyl Sulfate: A Review of Clinical Uses

HELENA A. JENKINSON, BS,* KELLY M. WILMAS, BS,* AND SIRUNYA SILAPUNT, MD†

BACKGROUND Sodium tetradecyl sulfate (STS) is Food and Drug Administration approved for treatment of varicose veins, but numerous other off-label applications have been reported.

OBJECTIVE To describe the clinical uses of STS, as well as efficacy and adverse effects.

METHODS Review of studies searchable on PubMed from 1938 to 2016 describing clinical uses of STS to determine efficacy and adverse effects associated with various applications.

RESULTS Sodium tetradecyl sulfate has shown efficacy in the treatment of varicose veins, telangiectasias, hemangioma, pyogenic granuloma, cherry angioma, Kaposi sarcoma, lymphangioma circumscriptum, digital mucous cyst, ganglion cyst, glomangioma, angiokeratoma of Fordyce, pseudocyst of the auricle, and verruca. Commonly reported side effects include pain, erythema, swelling, hyperpigmentation, telangiectatic matting, and ulceration. Serious side effects such as anaphylaxis, pulmonary embolism, stroke, and myocardial infarction have also been reported. Most sources were case reports and small prospective studies, as such the strength of data supporting many uses is limited by small sample sizes and lack of controls.

CONCLUSION Although not always the most effective method of treatment in off-label usage, use of STS has been frequently selected for a variety of applications for reasons of simplicity, low cost, lack of availability of technologically advanced equipment, and intricacies related to anatomic location.

The authors have indicated no significant interest with commercial supporters.

Sodium tetradecyl sulfate (STS) was first approved by the United States Food and Drug Administration (FDA) in 1946.¹ Although approved for treatment of small varicose veins, there have been numerous reported cases of use of STS for treatment of other conditions. Although not always the most effective method of treatment in off-label usage, use of STS has been frequently selected as monotherapy or adjuvant therapy for reasons of simplicity, low cost, lack of availability of technologically advanced equipment, and intricacies related to anatomic location. The purpose of this review is to alert the reader to the numerous reported dermatological applications of STS, as well as their efficacy and potential complications. It should be noted that much of the literature on the subject of these alternative uses involves case reports and case series involving very small sample sizes, often without controls. It is

therefore exceedingly difficult to rate the strength of the data available at this time.

Pharmacology

Sodium tetradecyl sulfate is an anionic detergent sclerosant that acts by disturbing the phospholipid membrane of cells. At high concentrations, STS causes solubilization of the membrane and subsequent cell lysis. At lower concentrations, the agent acts to create negative charge on the cell membrane of endothelial cells that induces coagulation.² The result of thrombotic occlusion is fibrosis and ablation of blood vessels.³

Formulations

Sotradecol is the only FDA-approved commercially available form of STS for use of injection in the US

*University of Texas McGovern Medical School at Houston, Houston, Texas; †Department of Dermatology, University of Texas McGovern Medical School at Houston, Houston, Texas

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ISSN: 1076-0512 • Dermatol Surg 2017;0:1–8 • DOI: 10.1097/DSS.0000000000001143

market.³ STS for injection use has also been sourced from compounding pharmacies. A study analysis of 3% STS solutions from 3 separate US compounding pharmacies revealed that all samples contained different concentrations than those written on the bottle (2.59%–3.39% STS).⁴ Compounded formulas were also found to contain increased concentrations of contaminants, including carbitol, versus non-compounded formulas^{1,4} and to result in increased frequency of segments of incomplete ablation.¹ Because of these impurities, use of compounded STS is not recommended and physicians are instead encouraged to use the branded product. According to the FDA-approved product labeling, the maximum single treatment dosage of STS is 10 mL.³

Sodium tetradecyl sulfate may be administered either in liquid form or foam after off-label conversion. There are numerous techniques used for producing foam from liquid STS, with the Tessari method being the most popular technique used currently.⁵ Foam displaces blood in the vessel, increasing the length of exposure of STS to endothelium and decreasing the rate of protein binding to STS, resulting in increased efficacy.^{5,6}

Clinical Uses

Label Usage

Leg Veins

A Cochrane review of 17 studies involving more than 3,300 patients examined the efficacy of sclerotherapy for treatment of varicose veins in the legs. Included

studies compared STS with alternative sclerosing agents and graduated compression stockings, there were no included randomized trials comparing use of STS with observation.⁷ Four selected studies compared use of STS with other sclerosing agents.^{8–11} Three studies found similar complication rates and efficacy between STS and other sclerosing agents (polidocanol and hypertonic dextrose).^{8–10} Labas and colleagues¹¹ found greater improvement of cosmetic appearance with STS versus polidocanol at 6 months, but the difference at 5-year follow-up was not significant. A randomized controlled trial involving 101 pregnant women demonstrated greater improvement of symptoms and cosmetic appearance of veins using STS versus graduated compression stockings.¹²

A Cochrane review regarding use of sclerotherapy for lower limb telangiectasias included 10 studies with 484 patients in total. It demonstrated increased patient satisfaction in the treatment arm versus placebo but did not show superiority of any particular sclerosing agent. The review also suggested that STS was more painful than heparin or polidocanol for sclerotherapy.¹³

Adverse effects that have been frequently reported in association with STS therapy for treatment of leg veins include pain, urticaria, ulceration, hyperpigmentation, cutaneous necrosis, and telangiectatic matting.^{7,14} Other rare complications that have been reported include pulmonary embolism, anaphylaxis, venous thrombosis, hypertrichosis, myocardial infarction, and stroke (Figures 1 and 2).^{14–17}

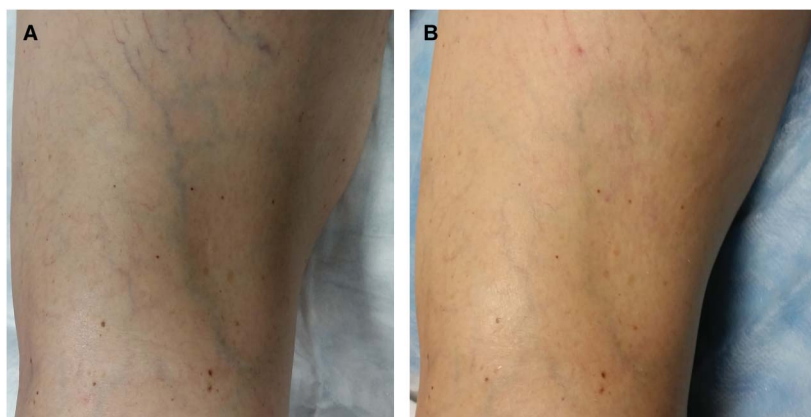


Figure 1. Leg varicose veins before (A) and after (B) sclerotherapy. Photo courtesy of Sirunya Silapunt, MD.



Figure 2. Spider veins on medial ankle before (A) and 5 months after (B) 2 treatments. Photo courtesy of Sirunya Silapunt, MD.

Off-Label Usage

Dorsal Hand Veins

Three studies were found pertaining to the use of STS in the treatment of dorsal hand veins. Duffy and colleagues¹⁸ reported an 80% failure rate in the treatment of dorsal hand veins in 10 patients with a 0.5% STS liquid formulation. Bowes and Goldman reported complete resolution in 11 of 14 hands treated with 1.5% to 3% STS, with an average improvement of 97.8% for all treatment sites. Adverse effects were limited to erythema and edema after injection.¹⁹ In a retrospective patient-reported outcome study performed by Tremaine and colleagues, complete (78.9%) or moderate (21.1%) satisfaction were reported in 21 patients treated with 0.25% to 1% STS foam for reticular veins of the dorsal hands. Adverse effects were limited to mild pain, erythema, bruising, edema,

temporary hyperpigmentation, and coagulum formation (Figure 3).²⁰

Facial Veins

Goldman and colleagues reported the use of 0.1% STS in 20 patients with telangiectasias of the nose, cheeks, and chin with 90% resolution. Complications included matting in 1 patient, punctate ulcer in 3 patients, and bruising in 15 patients. They also reported use of 0.5% STS in 2 patients with telangiectasias of the nose with 100% resolution; complications included bruising and spot necrosis. In the same study, STS was compared with treatment with hypertonic saline, as well as 0.5% and 1% polidocanol. The authors noted an increased rate of recurrence with hypertonic saline versus polidocanol or STS, but a reduced rate of complications.²¹ In a later article, Goldman observes that facial telangiectasias are typically less responsive to treatment with sclerosants than those of the legs. Because most facial telangiectasias are arteriolar in origin, there is an increased risk of skin necrosis. However, the telangiectatic matting and hyperpigmentation associated with injection of

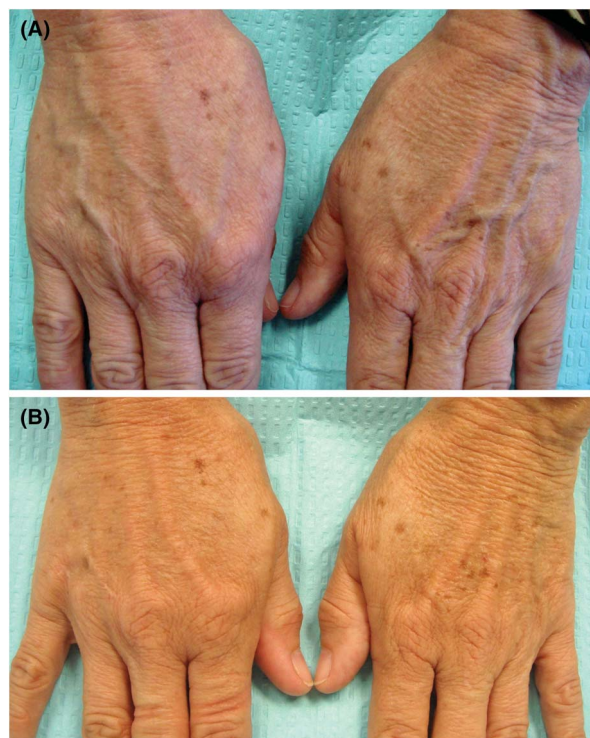


Figure 3. Dorsal hand veins before (A) and 9 months after (B) sclerotherapy. Photo courtesy of Sirunya Silapunt, MD.

telangiectasias of the legs occur less frequently after facial injection for unknown reasons.²²

Periocular Veins

Sodium tetradecyl sulfate has also been used for the cosmetic removal of periocular veins. A case series by Green describes successful treatment of periocular veins in 50 patients with 0.75% STS. Sodium tetradecyl sulfate was slowly injected using minimal pressure, and the needle was directed laterally so the flow was directed away from the midface. There were no recurrences as of 12 months after therapy, and the only adverse effect was transient purpura at the injection site in 6 patients.²³ Although no side effects were reported in this case series, Fante cautions that there is potential for sight-threatening complications from inadvertent intra-arterial injection during this procedure. He further states there is potential during injection of eyelids for STS to reach the ocular adnexae, central retinal vein, choroidal vortex veins, or cavernous sinus through anastomoses between the superficial facial and deep orbital venous systems.²⁴

Chest and Breast Veins

As with treatments of the hands and face, a limited number of studies have been published on STS treatment of reticular and telangiectatic veins of the chest and breast. Peterson and Goldman recommend a foam mixture of 1 mL STS to 4 mL room air or CO₂, using 0.25% and 0.5% STS for veins less than 1 mm and up to 3 mm diameter, respectively.²⁵ Bowes and Goldman reported 50% improvement of reticular chest veins in a patient after treatment with 1.5 mL of 0.25% STS and 4 mL of 0.5% STS; however, at 2-year follow-up, telangiectatic matting had developed on the periphery of one of the treatment sites. Reticular breast veins of another patient resolved completely after 2 sessions of sclerotherapy with 4 mL of 0.5% STS. At 1-year follow-up, an area of telangiectasia on the breast was treated with 0.5 mL of 0.25% STS; ischemia and ulceration developed weeks later over the treated area.¹⁹

Friedmann and colleagues conducted a telephone-based retrospective assessment of patient satisfaction with 0.25% and 0.5% STS foam sclerotherapy of reticular chest veins. Of the 12 patients who were

contacted, 10 reported being very satisfied with the treatment outcome. Seven patients reported complete resolution, 3 reported moderate improvement, and 1 reported mild improvement. Reported adverse effects included edema, erythema, ecchymosis, telangiectatic matting, and mild coagulum.²⁶

Hemangioma

Numerous case reports and case series have described treatment of oral and cutaneous hemangiomas with STS. Regression of lesions has been reported with liquid and foam STS, with 3% liquid STS being most frequently used.^{27–31} The number of injections necessary to achieve resolution of lesions ranged from 1 to 15, with variables including size and location of lesion, resistance to previous treatments, as well as method of administration.

Minkow and colleagues described treatment of 24 patients with hemangiomas of the oral cavity and lips with 3% STS with complete regression of all lesions. Pain and swelling were the only complications.²⁸ Agarwal reported treatment of 20 oral hemangiomas with 3% STS. Reinjection was performed as needed at 2 to 4 week intervals with a maximum of 10 treatments. All but 1 lesion underwent complete regression. Complications included pain, ulceration, sloughing, and palatal perforation.²⁹ Woods reported “modest to striking improvement” in 16 of 18 patients with hemangiomas and related lesions treated with 3% STS. Complications were limited to sense of “uneasiness” and minor superficial desquamation.³⁰ Harjai and Jha treated 30 patients with peripheral hemangiomas with 2% STS injections, with complete resolution in 40% of patients and greater than 50% regression in an additional 20% of patients. Complications included pain, skin discoloration, edema, leukocytosis, and fever.³¹ The length of follow-up was unspecified in all 4 of the studies described above.^{28–31}

Pyogenic Granuloma

Pyogenic granulomas, including oral and sub-ungual lesions, have also been successfully treated with intralesional STS injection. Samatha and colleagues reported the use of STS injection at an unspecified concentration for treatment of oral pyogenic granulomas in 5 patients. Follow-up

occurred at regular 1-week intervals, with reinjection performed until lesions became necrotic and fell off. The authors reported complete resolution of lesions in 4 of the 5 patients after 1 to 4 injections, with no recurrence as of 3 months follow-up. In the fifth patient, the lesion became fibrosed after the second treatment and complete excision of the lesion was performed. One patient experienced pain and edema.³² Moon and colleagues reported a study involving the use of 0.5% STS injection in treatment of 14 patients with 15 pyogenic granulomas. Lesions were reinjected at 1 to 2 week intervals as needed. Six weeks after the final treatment, complete resolution of 12 of 14 lesions was observed (1 patient was not available for follow-up).³³ In a separate case report, Moon reported the use of 0.5% STS solution in the treatment of a subungual pyogenic granuloma, with complete resolution after 2 treatments. There were no adverse reactions, and there was no recurrence as of 16 months after treatment.³⁴ Nirmal and colleagues³⁵ reported a case of Nicolau syndrome with pain and livedoid changes of the thumb in a patient after injection of 0.1 mL of 1% STS into a pyogenic granuloma on the palm.

Cherry Angioma

Jairath and colleagues performed a prospective study of STS therapy for cherry angiomas in 20 patients with combined 100 cherry angiomas, each greater than 0.2 mm in size. Intralesional injection of 0.1 mL of 3% STS was performed, with weekly reinjection as needed. All lesions responded to therapy, with 42 healing after first injection, 44 healing after second injection, 2 healing after third injection, and 12 healing after fourth injection. There was no recurrence at 2 weeks after completion of treatment. Adverse effects included ulceration (17%), scabbing (24%), mild scarring (11%), and postinflammatory hyperpigmentation (16%).³⁶

Kaposi Sarcoma

There are several reports of the usage of STS as an alternative therapy for both oral and cutaneous Kaposi sarcoma (KS) because of relative safety, reduced cost, and simplicity of use. Lucatorto and Sapp reported treatment of 15 oral KS lesions in 12

patients with AIDS. Multiple injections of 3% STS were made in the lesion itself and normal surrounding tissue. A second treatment was required in 6 patients. Ulceration occurred in all lesions by the second week, causing moderate to severe pain in 1 to 2 patients. No recurrences were reported, with 9 of 12 patients followed 6 to 18 months after injection.³⁷ Muzyka and Glick described injection of 3% STS into 14 nodular oral KS lesions in 12 patients with AIDS. Injections were repeated every 3 days, if there had been no response. Lesions decreased an average of 80% within 14 to 21 days, with complete disappearance in 4 patients. There was no further progression in any patients as of follow-up evaluation at 24 weeks after treatment and no adverse effects were reported.³⁸ In a double-blind, randomized trial, Ramirez and colleagues compared 1-time injection of vinblastine intralesionally versus STS perilesionally, with 8 HIV-infected patients assigned to each group. Results were comparable for both therapies, with a mean tumor size reduction of 0.68 cm in patients treated with vinblastine and 0.61 cm in those treated with STS. Transient pain and superficial ulceration were reported in both groups.³⁹

Kim and colleagues reported use of STS for treatment of biopsy-proven KS lesions on the foot and ankle of a 96-year-old woman with blood test negative for HIV antibody. Sodium tetradecyl sulfate was chosen as palliative treatment for KS, rather than more aggressive treatments such as intralesional chemotherapy, given the patient's age and state of health. Six injections of 3% STS resulted in reduction of size of lesions without any complications.⁴⁰

Lymphangioma Circumscriptum

Four case reports that described use of STS as a treatment for lymphangioma circumscriptum were found. Concentrations of 0.1% to 1% STS were used, and multiple treatments were required in all patients. Results were variable, with complete resolution in 1 patient,⁴¹ partial improvement in 2 patients,^{42,43} and no improvement in 1 patient.⁴⁴ Adverse effects associated with treatment included pain, postinflammatory hyperpigmentation, and mild atrophic scarring.^{41,43}

TABLE 1. Uses of STS

Condition	Efficacy
Varicose veins	Cochrane review of 17 studies showed improvement of symptoms and cosmetic appearance of leg varicose veins with sclerotherapy ⁷ with comparable efficacy between STS and other sclerosants ^{8–10}
Reticular veins	Complete resolution in 20/38 and moderate improvement in 17/38 lesions on dorsal hands, ²⁰ successful treatment of periocular veins with caution regarding visual complications, ^{23,24} variable results and limited number of studies on chest and breast reticular veins ^{19,26}
Telangiectasias	Successful treatment of legs ¹³ and face, ²¹ with no shown superiority of any particular sclerosant for leg telangiectasias ¹³
Hemangioma	Complete regression in 24/24, 19/20, and 12/30 lesions treated with 2%–3% STS in 3 studies, as well as “modest to striking improvement” in 16/18 lesions in another study; length of follow-up unspecified in all 4 studies ^{28–31}
Pyogenic granuloma	Complete regression of 4/5 and 12/14 lesions in 2 studies of oral and subungual pyogenic granulomas; no recurrences at 6–12 week follow-up ^{32,33}
Cherry angioma	20 patients with a combined 100 lesions, all of which responded to injection with 3% STS ³⁶
Kaposi sarcoma	Reductions in size of oral lesions in 3 studies, involving 32 patients treated with 3% STS ^{37–39}
Lymphangioma circumscriptum	Partial to complete resolution in 3 of 4 patients treated with 0.1%–1% STS ^{41–44}
Digital mucous cyst	Successful treatment in 3 studies, with complete regression of 11/12, 15/15, and 16/20 lesions; follow-up period ranged 2–60 months ^{45–47}
Ganglion cyst	Two studies involving 192 patients showed resolution of lesions with therapy, but approximately 35% rate of recurrence ^{48,49}
Glomangioma	One patient with greater than 50 lesions successfully treated with variable concentrations (0.2%–3%) of STS ⁵¹

TABLE 1. (Continued)

Condition	Efficacy
Angiokeratoma of Fordyce	Three patients successfully treated with 0.25% STS ⁵²
Pseudocyst of the auricle	One patient successfully treated with 1% liquid STS ⁵³
Verruca	Fifty-one patients treated with jet spray STS for plantar verrucae with a 72% “cure” rate ⁵⁴
STS, sodium tetradecyl sulfate.	

Digital Mucous Cyst

Three studies were found that described successful use of STS as a treatment for digital mucous cysts. Sung and Roh reported injection of 12 digital mucous cysts with 0.5% STS, with complete regression occurring in 11 lesions after an average of 2.4 treatments. The mean follow-up period was 18.3 months. Edema, erythema, pain, and inflammation were seen in 3 of 12 lesions.⁴⁵ In a separate study, Audebert reported complete resolution of 15 digital mucous cysts after 1 to 3 treatments with 3% STS. One lesion recurred after 3 years and was successfully retreated.⁴⁶ Park and colleagues reported STS treatment of 20 digital mucous cysts of which 80% resolved completely, with an average follow-up period of 16 months. In their study, 15 finger lesions were injected with 1% STS, and 5 toe lesions were injected with 3% STS with the rationale that toe lesions are more difficult to treat and more likely to recur. Injection was repeated at 4-week intervals as needed. The total number of injections ranged from 1 to 7, with mean of 2.3. Mild superficial necrosis occurred in 6 patients, with one experiencing scarring and mild nail deformation as a result.⁴⁷

Ganglion Cyst

Several reports of STS used in the treatment of ganglion cysts have shown efficacy, but with substantial recurrence and some adverse events. Chatterjee and colleagues compared the use of STS, triamcinolone, and hyaluronidase, in the treatment of ganglion cysts, with 60 patients in each group. Cyst contents were aspirated and then the cyst was injected with 2 mL of sclerosing agent. Pain, wrist stiffness, ulceration, and hypersensitivity reactions occurred as side effects of STS therapy. Follow-up ranged 6 to 18 months and

showed a 35% rate of recurrence in patients injected with STS (vs 20% with triamcinolone and 31.67% with hyaluronidase).⁴⁸ Ajekigbe and Stothard⁴⁹ reported use of STS in treatment of 137 wrist ganglion cysts in 132 patients. Ninety-nine percent of lesions responded to therapy, and 90% resolved after the first injection. The remaining lesions resolved after 2 to 3 injections. A follow-up questionnaire was sent to patients at a minimum of 2 years after treatment. Of the 55 patients who responded, 35% had recurrence within 3 to 5 years. No complications were reported.⁴⁹

In a letter to the editor, Jalul and Humphrey alerted readers to the case of a patient who developed radial artery injury after treatment of a left palmar wrist ganglion with STS. The lesion was aspirated and injected with an unspecified strength of STS and then reinjected 6 weeks later. The index finger and distal thumb became gangrenous after the second injection, requiring amputation.⁵⁰

Glomangioma

Parsi and Kossard reported successful treatment of multiple hereditary glomangiomas with STS in a patient with greater than 50 lesions located on his extremities, trunk, and face, ranging from 3 to 40 mm in diameter. Sodium tetradecyl sulfate concentration of 0.2% to 3% STS was injected and subsequently reinjected as needed, at 2 to 4 weeks intervals. The total number of injections ranged from 1 to 4, with an average of 2. There were no complications and no recurrences of treated lesions at 12 months of follow-up.⁵¹

Other Clinical Uses

Numerous other applications of STS have been described in addition to those listed above. Sodium tetradecyl sulfate injection was reported as a successful treatment for angiokeratoma of Fordyce in 3 patients (0.25% liquid STS) and pseudocyst of the auricle in 1 patient (1% liquid STS).^{52,53} In addition, in 1969, Locke and Zang described the use of a jet spray injection of STS for treatment of plantar verrucae in 51 patients with a 72% “cure” rate.⁵⁴

Conclusion

The purpose of this article is to familiarize the reader with the numerous dermatological applica-

tions of sodium tetradecyl sulfate, as well as the efficacy and complications associated with these uses (Table 1). Although not always the most effective method of treatment in off-label usage, use of STS may be selected when other methods are not practical for reasons such as availability of advanced equipment, cost, and intricacies of anatomic location. It may also be used to reduce size of lesions before surgical excision or as an adjunct with other therapies.

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Address correspondence and reprint requests to: Sirunya Silapunt, MD, Department of Dermatology, University of Texas McGovern Medical School at Houston, 6655 Travis Street, Suite 980, Houston, TX 77030, or e-mail: Sirunya.Silapunt@uth.tmc.edu