Catheter-directed sclerotherapy

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Abstract
Background: Catheter directed sclerotherapy (CDS) involves the use of a long catheter to deliver a sclerosing agent into a target vessel (saphenous trunks or venous malformations) under ultrasound guidance.
Aims and Methods: This article reviews the history, current techniques and devices and the evidence as it relates to these procedures.
Results: CDS was developed to increase the safety and efficacy of ultrasound-guided sclerotherapy (UGS). With the advent of foam sclerosants and tumescent anaesthesia, the procedure has enjoyed a higher primary success rate. CDS has a better safety profile when compared with UGS with virtually no risk of intra-arterial injection or sclerosant extravasation. Compared with endovenous laser (EVLA) and radiofrequency ablation (RFA), CDS is a quicker procedure with less associated pain. Some balloon catheters, however, have been found to force the sclerosant down the perforators causing femoral vein occlusion. Based on the current level of evidence, no firm conclusion regarding the efficacy of CDS techniques can be drawn in comparison with EVLA or RFA, but the primary success rate is probably higher than the standard UGS.
Conclusion: CDS ensures a safe intraluminal delivery of the sclerosing agent into the trunk of the saphenous veins using a single access point. This procedure preceded EVLA and RFA, and remains a safe alternative for the treatment of saphenous incompetence and venous malformations.

Keywords: sclerotherapy; ultrasound-guided sclerotherapy; catheter-delivered foam; varicose vein; saphenous vein

Introduction
The modern management of varicose veins has evolved to incorporate endovascular and image-guided techniques (Table 1). Ultrasound-guided sclerotherapy (UGS) was first described in 1986 and involves the introduction of a sclerosing agent into the lumen of a target vessel under the guidance of duplex ultrasound.1,2 This technique has been shown to be effective in the treatment of incompetent truncal veins, tributaries, perforators and postsurgical recurrences.3,4

Intravenous catheters or ‘long lines’ have been used as central or peripheral lines for the introduc-

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leaves of *Allium fistulosum*, an onion plant, coated with lacquer, as catheters around 100 BCE. The Roman physician Claudius Galen (138–201 CE) invented an S-shaped metal catheter that was used throughout antiquity.

Until the ninth century, catheters were made of gold, silver and copper with one curve to follow the normal curvature of the male urethra. The Persian physician and alchemist, Razi (Rhazes) (841–926 CE) invented the first malleable catheter from lead. In 1036, another Persian physician Avicenna (980–1037 CE) (Figure 1) invented the first fully flexible catheter made from marine skin with side holes and a rounded firm tip. Of interest to phlebologists, Avicenna described the anatomy of the saphenous vein in detail and named this vein *Safina* (‘the hidden’).

Table 1  Evolution of catheter-directed sclerotherapy

<table>
<thead>
<tr>
<th>Technique or device</th>
<th>First author</th>
<th>Year</th>
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<tr>
<td>Description of Safina vein</td>
<td>Avicenna</td>
<td>1025</td>
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<tr>
<td>Flexible catheter</td>
<td>Avicenna</td>
<td>1036</td>
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<tr>
<td>Vascular catheterization</td>
<td>Bleichroeder</td>
<td>1912</td>
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<td>Modern flexible catheter</td>
<td>Sheridan</td>
<td>1940s</td>
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<tr>
<td>X-ray-guided catheterization</td>
<td>Seldinger</td>
<td>1953</td>
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<td>Balloon embolectomy catheter</td>
<td>Fogarty</td>
<td>1963</td>
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<td>UGS</td>
<td>Schadeck</td>
<td>1986</td>
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<td>Catheter sclerotherapy</td>
<td>Gatto</td>
<td>1989</td>
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<td>‘Open catheter’ UGS</td>
<td>Grondin</td>
<td>1992</td>
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<td>Phlebocath</td>
<td>Robert</td>
<td>1995</td>
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<td>ELLE</td>
<td>Parsi</td>
<td>1997</td>
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<td>Balloon CDS</td>
<td>Gonzales Zeh</td>
<td>2005</td>
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<td>KA/S</td>
<td>Brodersen</td>
<td>2007</td>
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<tr>
<td>Pulse spray technique</td>
<td>Almeida</td>
<td>2008</td>
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CDS, catheter-directed sclerotherapy; UGS, ultrasound-guided sclerotherapy

In 1912, German scientists Bleichroeder, Unger and Loeb published the first report of human vessel catheterization using elastic rubber catheters. They successfully catheterized the axillary vein via the forearm and the inferior vena cava via the femoral vein.

In the 1940s, the American inventor David S Sheridan invented the modern disposable catheter. He is also credited with the invention of the modern disposable endotracheal tube now used routinely in surgery. In 1953, the Swedish radiologist Sven-Ivar Seldinger (1921–1999) (Figure 2), published his X-ray-guided percutaneous catheterization technique, which involved the entry of a guidewire over which a sheath glides to gain access to any part of the body. The Seldinger technique formed the foundation of the modern interventional medicine and has gained multiple applications in radiology, urology, anaesthesics, intensive care, vascular medicine and, more recently, in phlebology. In 1963, the American physician Thomas Fogarty invented the balloon embolectomy catheter, which itself revolutionized surgical embolectomy procedures.

Catheters are now made of latex, silicone or teflon. There are three major types of catheters: coronary,
renal and infusion. Coronary catheters are used for angiography, angioplasty and ultrasound-guided procedures involving the heart or peripheral vessels.

**Catheters and UGS**

*Ultrasound-guided sclerotherapy*

The French phlebologist, Michel Schadeck, performed the first known UGS procedure in 1984 (personal communication), presented his work in 1985 and later published the same in *Phlebologie* in 1986. Later in 1986, the Argentinian Juan de Simone presented his echographic-guided technique of sclerotherapy in the Kyoto meeting of the Union Internationale Phlebologie (UIP). Three years later, Knight and Zygmunt presented their technique of UGS of lower limb veins in Strasbourg.

*Early works*

In the proceedings of the 1989 World Congress of UIP in Strasbourg, an abstract by Gatto details his video presentation of injecting a liquid sclerosant into the great saphenous vein using a catheter in a 40-year-old man. This is the earliest documented description of CDS.

*‘Open catheter’ UGS*

The Canadian phlebologist, Louis Grondin (Figure 3), pioneered the use of endovascular access in sclerotherapy. In 1992, he described his ultrasound-guided technique of cannulating the saphenous trunks, 6–8 cm distal to the relevant junctions, using a 20G 44 mm cannula. The sclerosant liquid was then injected as a bolus while the target vein was monitored on ultrasound. Compared with UGS, this technique offered an increased safety profile for the delivery of the sclerosants to the incompetent junctions and in particular the saphenopopliteal junction, where the risk of intra-arterial injection was considered significant.

*Phlebo-cath®*

In 1995, Robert and Robert published their technique of ‘Echocatheterization’ using Phlebo-cath® (Vygon, Ecouen, France), a catheter device specifically developed for sclerotherapy. This catheter was used to treat axial reflux in saphenous veins. The tip of the catheter was echogenic and had no distal orifice but three side holes through which the sclerosant was injected. This report had no statistical study and the puncture was not performed under duplex guidance, which only controlled the position of the tip of the catheter.

*ELLE*

The author was inspired by Grondin’s ‘open catheter’ technique and developed a long line catheter-guided technique, the Extended Long Line Echosclerotherapy (ELLE), first published in 1997. This technique was later presented in 1998 and further documented in detail in 2000. The target vessel (usually the great or small saphenous vein) was cannulated under ultrasound guidance at the level of the knee, medial or lateral ankle (Figure 4a). A long line catheter such as Cavafix MT or Cavafix Certo (B Braun Medical Suppliers, Sydney, Australia) was passed into the vessel and advanced proximally. Once the catheter was about 5 cm away from the junction, the leg was elevated to about 45° to empty the vein and the position of the tip was confirmed on ultrasound (Figure 4b). The sclerosant was then introduced using pulse injections as the catheter was withdrawn. An average of 3–5 mL of sodium tetradecyl sulphate 3% was injected along the whole length of the vein under ultrasound visualization. Pulse injections of the liquid agent via 1 mL syringes were preferred to a continuous and gradual infusion of sclerosants. This was to generate turbulent flow and froth, which would maximize the contact of the sclerosant with the vessel wall. Distal segments and tributaries were treated using the standard UGS procedure.
Non-compressibility of the vessel was ultrasonically confirmed at the end of the session (Figure 4c). Class II graduated compression stockings were applied and maintained for one week. ELLE involved the catheter passing through a cannula to enter the vessel. This technique was later modified to the Seldinger method of using a guidewire and an introducer sheath as described by Min and Navarro.\textsuperscript{17}

**Advanced competitors and the resurrection of CDS**

Soon after ELLE, endovenous laser (EVLA) and radiofrequency ablation (RFA) techniques were developed using the same catheter principles. With the addition of tumescent anaesthesia, these new ablative techniques were found to have high primary success rates and replaced other alternatives and in particular stripping in many countries.\textsuperscript{18,19} However, the relatively high consumable cost of these procedures and reimbursement issues kept CDS alive as a treatment option for truncal incompetence. With the introduction of foam, CDS achieved a higher primary occlusion rate and further attempts were made to make this procedure more effective. Notable modifications have included the development of balloon catheters, catheters with side holes or side slits, combining CDS with tumescent anaesthesia, and using infusion pumps to pulse spray the liquid agent.

**Current techniques and devices**

**Balloon catheters**

Techniques using balloon catheters were developed to prevent the flow of sclerosants beyond the junctions and into the deep venous system.\textsuperscript{20,21} One such device, Varicath (VeinRx Inc., Miami, FL, USA), comprised a distal occlusion balloon and a variable infusion length catheter body with infusion holes.\textsuperscript{21} Almeida reported the results of 75 saphenous veins treated with this catheter. At six-month follow-up, the primary closure rate was 87\%, and the primary assisted closure rate was 96\%.\textsuperscript{22} Three limbs (4\%) were treated for asymptomatic deep vein thrombosis (DVT) formed at sites of decreased flow in femoral veins. In all three cases, foam was forced into the femoral vein, via thigh perforators most likely because the balloon blocked the outflow into the common femoral vein. This device has not been commercially available.

**KAVS**

The KAVS catheter (Catheter Assisted Venous Sclerosis, Richter & Rothe AG Co., Leipzig, Germany) is a double-lumen polyurethane catheter with a latex balloon element at the tip (Figure 5a). One lumen is used to inflate the balloon, while the second lumen is used to inject and then aspirate the foam back.\textsuperscript{20} There are only three side holes present just below the balloon (Figure 5b). The target vessel is accessed under ultrasound guidance and the position of the tip of the catheter is determined (Figure 5c). The foam is released from the side noted and is then massaged distally. Ten millilitres of foam is usually required to complete the treatment. The balloon obstructs the junction (Figure 5d) and, to prevent the flow into the deep veins via the perforators, the injected foam and the residual intravascular blood is aspirated back at the end of the treatment session (Figure 5e). In their pilot study of 30 patients, the authors report a 90\% GSV closure rate with no significant side-effects.\textsuperscript{20} In a follow-up of two years, no DVT has been detected in this cohort of patients (personal communication).
(Le Maitre Vascular, Burlington, MA, USA). To prevent the flow of excess foam into the femoral vein, perforators were located by duplex imaging and surgically clipped (Lega clip 20/20, Ethicon, Somerville, NJ, USA) using a clip applicator. To access the perforators, a small incision was made under local anaesthesia. The number of perforators clipped ranged from zero to four. With this catheter, the balloon stays inflated near the junction and as the foam is injected along the length of the vein, the introducer and the sheath are withdrawn. In this way, the whole length of the target vessel is exposed to the sclerosing foam. At three-month follow-up, all treated veins remained completely occluded and no DVT was detected on duplex scanning. This approach was challenged by Morrison who reminded the authors that the perforators seen by duplex scan represent only a minority of the actual number of perforating veins and that some may become competent after the treatment of the trunk. 24
Summary

In summary, CDS ensures a safe intraluminal delivery of the sclerosing agent to the trunk of the saphenous veins using one access point. When combined with tumescent anaesthesia, the sclerosant can be administered to an 'empty vein' avoiding dilution and neutralization, and maximizing endothelial exposure. Most open catheter techniques can deliver a consistent dose of the sclerosants along the entire length of the vein. This procedure preceded EVLA and RF ablation and remains a safe alternative for the treatment of saphenous incompetence.

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References

10 Seldinger SI. Catheter replacement of the needle in percutaneous arteriography; a new technique. Acta Radiol 1953;39:368–76
11 De Simone J. Appréciation de L'Effet Sclérosant avec L'Emploi de l'Echographie Veineuse et le Doppler. World Congress, Union Internationale de Phlébologie, Kyoto, Japan, 1986
12 Knight RM, Zygmunst JA. Injection into the SIEV: a previously very difficult injection. World Congress, Union Internationale de Phlébologie; Strasbourg, France. 1989: 789–90


22 Almeida JL, Raines JK. Catheter-directed sclerotherapy for saphenous vein incompetence. An update on the recent progress and current areas of clinical study and development using this therapeutic option. Endovasc Today 2005;39:32–4


28 Uloa J. Catheter foam sclerotherapy for the treatment of greater saphenous vein incompetence: endovascular occlusion foam, ENOF. Fifteenth World Congress, International Union of Angiology; Rio de Janeiro, Brazil, 2005


