INTRODUCTION

The literature data show an overall inferiority of ultrasound guided foam sclerotherapy (UGFS) in terms of the venous occlusion rate compared with other endovenous techniques, such as laser and radiofrequency, or surgery ***(O'Flynn et al., 2014).***

Ultrasound guided foam sclerotherapy has been proved effective and safe in the treatment of saphenous veins, tributaries, perforators, recurrences, venous malformations, and venous ulcers, but data on UGFS studies show an increased recanalisation rate for larger saphenous diameters ***(Rabe et al., 2015).***

In the presence of larger veins a larger volume of blood in the target veins negatively impacts any sclerosant activity by deactivating liquid and foamed sclerosant drugs both in vitro and in vivo, even after a few seconds ***(Cavezzi et al., 2017).***

The introduction of a catheter as the means of sclerosant foam (SF) delivery has been proposed in order to have a more even SF distribution to possibly improve the results ***(Cavezzi et al., 2017).***

The positioning of a catheter in a vein allows use of ultrasound guided peri-saphenous infiltration of the tumescent solution (PST) to reduce the vein caliber, and hence blood content, prior to sclerosant foam delivery ***(Cavezzi et al., 2015).***

Sclerotherapy can be used to treat a large range of vein sizes from telangiectasias to large varicose veins, the primary intent of sclerotherapy is to effectively eliminate the target vein after the highest point of reflux is treated. Sclerotherapy entails several different methods to deliver a sclerosing agent, depending on the diameter of the target vein ***(Baccaglini et al., 1997).***

Foam sclerotherapy involves the addition of air to a detergent sclerosing agent by means of agitation to produce a foam like consistency, which allows enhanced contact with the vein wall on injection. Because the sclerosing agent must make contact with the vein wall to cause endothelial damage, the primary limitation of sclerotherapy is vein diameter ***(Gloviczki et al., 2011).***

Effective interaction with the vein wall may be encumbered by blood flow within larger veins that dissipates the agent. An innovative method using a catheter to deliver sclerosants has also emerged as an option for larger veins ***(Bergan, 2008).***

Sclerosing agents are most commonly grouped into categories based on their mechanism of action for producing endothelial damage, sixteen categories of currently available solutions are osmotics, alcohol, and detergents ***(Weiss et al., 2001).***

Ideal sclerosing agents can effectively damage the endothelium, exhibit a low incidence of adverse events, and are painless to inject. Relative contraindications to sclerotherapy include asthma, late complications of diabetes, hypercoagulable state, leg edema, advanced peripheral arterial occlusive disease, and chronic renal insufficiency ***(Goldman and Weiss, 2001).***

Absolute contraindications are a known allergy to the sclerosant, acute cellulitis, acute respiratory or skin disease, severe systemic disease, phlebitis migrans, acute superficial thrombophlebitis, pregnancy, hyperthyroidism, and bedridden status ***(Goldman and Weiss, 2001).***

The original method that is widely used today and involves the use of a three-way stopcock connected to two syringes was developed by Tessari in 1999. One of the main criteria for foam to be viable is that bubble size must be 100 μm or less ***(Frullini et al., 2002).***

The pure form of the sclerosing agent is contained on the bubble surface; therefore, concentration is related to bubble size. Other factors that contribute to success with foam sclerotherapy are stability and longevity ***(Cavezzi et al., 2002).***

Depending on the size and depth of the target veins, duplex ultrasound is very helpful in guiding the injection of foamed sclerosants ***(Zimmet, 2003).***

If ultrasound-guided sclerotherapy (USGS) is to be used, incompetent target vein segments should be marked before the procedure. It is important to adjust the amount of foam injected on the basis of the diameter and length of the target vessel ***(Guex, 2007).***

Because foam is highly visible under ultrasound, the use of ultrasound guidance enhances efficacy and reduces complications. It also enables immediate post injection observation of vein compressibility as a predictor of treatment efficacy ***(Kanter, 1998).***

The use of a catheter under ultrasound guidance that has been described involves placement of an end-hole catheter distal to the SFJ, similar to the technique used for endovenous ablation ***(Guex, 2007).***

The catheter is then withdrawn while the user delivers a foamed sclerosing agent under ultrasound guidance. Kolbel et al achieved clinical success with a comparable method consisting of delivery of foamed polidocanol through a long introducer sheath as it was retracted through the GSV ***(Kolbel et al., 2007).***

The foam is foamed via the Tessari method and delivered through the micro-access sheath while it is withdrawn through the vessel segment. Other than these methods, little research has been done with catheter-directed sclerotherapy, and this is certainly an area for growth and consideration in the future because it is a lower-cost alternative to endothermal ablation procedures ***(van Eekeren et al., 2013).***

AIM OF THE WORK

To highlight the role of duplex guided foam sclerotherapy in management of primary varicose vein which is an efficient, relatively cheap, and a safe modality in the treatment of great saphenous vein varicosities.

Chapter 1

ANATOMY

Venous anatomy is very variable in some parts but more constant in other parts of the lower limbs. Common variations in lower limb venous anatomy are described in this section ***(Cavezzi et al., 2006).***

Thorough knowledge of the fascial compartments of the leg is a prerequisite of understanding the relationship between superficial and deep veins. The fascia surrounding the calf and thigh muscles separates two compartments: the superficial compartment, consisting of all tissues between the skin and the fascia, and the deep compartment, which includes all tissues between the fascia and the bones **(Figure1).**

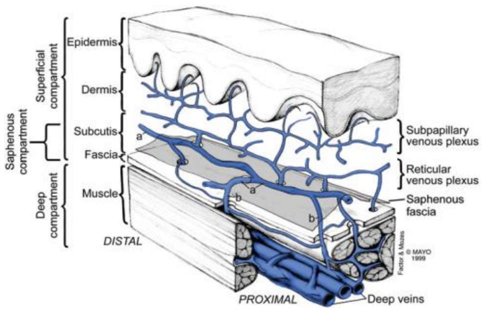

Figure (1): Relationship between the fascia and veins of the lower extremity. The fascia covers the muscle and separates the deep from the superficial compartment. Superficial veins (a) drain the subpapillary and reticular venous plexuses, and are connected to deep veins through perforating veins (b). The saphenous fascia invests the saphenous vein. The saphenous compartment is a subcompartment of the superficial compartment ***(Bergan, 2007).***

Superficial veins run in the superficial, deep veins in the deep compartments. Perforating veins pierce through the fascia and connect the superficial to deep veins. Communicating veins connect veins within the same compartment: superficial to superficial or deep to deep veins. The saphenous veins are covered by a fibrous sheath, the saphenous fascia. The saphenous fascia is thinner than the deep fascia and it is more pronounced in the upper-mid thigh, than more distally ***(Caggati 2001).*** The space between the saphenous and muscular deep fascia is the saphenous compartment. The saphenous compartment is a subcompartment of the superficial compartment ***(Bergan, 2007).***

The superficial venous system of the foot is divided into the dorsal and plantar subcutaneous venous network **(Figure 2).** Superficial vein tributaries drain blood into the dorsal venous arch on the dorsum of the foot at the level of the proximal head of the metatarsal bones. The medial and lateral end of this arch continues through the medial and lateral marginal vein into the great (GSV) and small saphenous veins (SSV), respectively ***(Caggati 2001).***

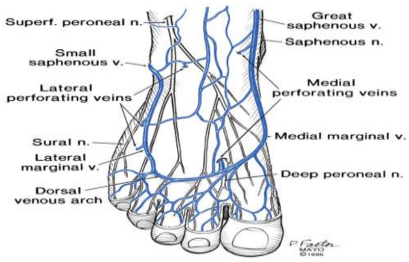

Figure (2): Superficial and perforating veins of the foot and ankle ***(Bergan, 2007).***

Proximal to the knee, the GSV ascends on the medial side of the thigh and enters the fossa ovalis 3cm inferior and 3cm lateral to the pubic tubercle. The GSV is doubled in the calf in 25% of the population, in the thigh in 8%. The saphenous nerve runs in close proximity to the GSV in the distal two-thirds of the calf ***(Scultetus et al., 2001).***

Accessory great saphenous veins are frequently present and they run parallel to the GSV both in the thigh and in the leg; they lie anterior, posterior, or superficial to the main trunk. The posterior accessory GSV of the leg (Leonardo’s vein or posterior arch vein) is a common tributary, it begins posterior to the medial malleolus, ascends on the posteromedial aspect of the calf, and joins the GSV distal to the knee ***(Bergan, 2007).***

Rarely, the GSV terminates high on the lower abdomen or joins the femoral vein very low and the superficial inguinal veins empty individually into the femoral vein. Other occasional tributaries of the GSV in the groin include the posterior and anterior thigh circumflex veins ***(Bergan, 2007)*****.**

Venous anatomy hasn’t changed over the years but the terminology that we use to describe it has been standardized. Anatomic terminology is the foundation of medical communication. Effective exchange of information is possible only if a common terminology is used. This is important for investigation of the venous system of the lower extremities and for accurate diagnosis and proper treatment. The difficulty in understanding the venous anatomy of the lower extremities has been enhanced by the variable terminology that has been used. Changes were adopted that will facilitate an effective global exchange of information. As phlebologists, we must lead the way to eliminate confusing names like “superficial” femoral vein in the deep system and abbreviations like “LSV” in the superficial system ***(Mauriello, 2011).***

The way we study the anatomy of the lower extremity veins has changed dramatically. With duplex imaging we can observe the veins of the lower extremity in a way much different than previous anatomic or surgical dissection. Observing the veins in full distention (standing) allows precise anatomic and pathologic visualization in relation to their surrounding anatomic structures, especially the muscle and fascial layers. This noninvasive, repeatable, low cost tool allows us to collect vast amounts of data on both normal anatomy and pathological patterns creating a need for a common terminology ***(Bergan, 2007).***

In an effort to attempt the impossible, and weave the classical terminology with the clinical nomenclature of the veins of the lower limbs, the International Union of Phlebology (UIP) commissioned an international interdisciplinary consensus statement, which was published in the Journal of Vascular Surgery in August 2002 along with refinements of that nomenclature in April 2005 ***(Caggiati et al., 2005).***

The following section defines the main ultrasound markers of anatomy of the veins of the lower limbs, according to the published literature, and the anatomy of veins considered to be relevant for clinical practice and for research in GSV disease is presented. Some anatomical variations that have been reported in the published literature will be discussed as well ***(Cavezzi et al., 2006).***

Ultrasound markers of venous anatomy

A- The saphenous eye: Ultrasound appearances identify the main saphenous trunks within their fascial compartments. Bailly was the first to describe the 'eye sign' to identify the GSV in the thigh by ultrasound. A more detailed description of the saphenous compartment has been published more recently *(Lemasle et al., 1996 & Caggiati et al., 1997).* The sign is due to the fact that superficial fascia is echogenic and easily observed on ultrasound **(Figure 3)** ***(Cavezzi et al., 2006).***

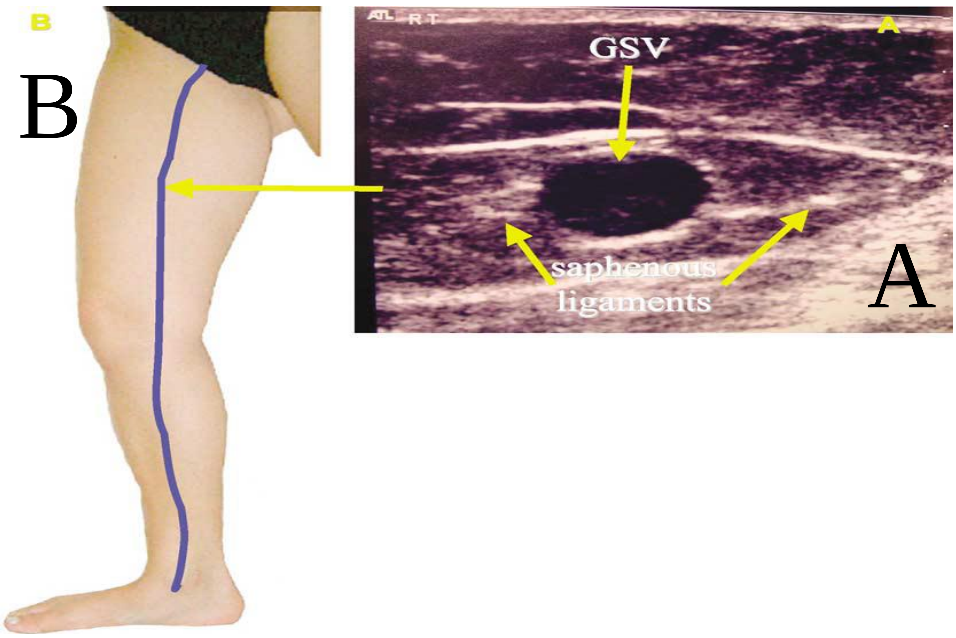

Figure (3): (A) Transverse B mode ultrasound image of the great saphenous vein (GSV) in the saphenous compartment of the thigh. (B) Position of the ultrasound probe in the thigh ***(Cavezzi et al., 2006).***

The compartment in which the saphenous trunks run resembles an ‘Egyptian eye’ in a transverse scan where the saphenous lumen is the iris, the superficial fascia the upper eyelid, and the aponeurotic deep fascia the lower eyelid. The deep layer arises from the muscle fascia and is usually better defined than the superficial or saphenous fascia. The ‘eye’ sign is always present and allows the saphenous vein to be clearly identified and distinguished from parallel subcutaneous tributaries ***(Cavezzi et al., 2006).***

B- Alignment sign: The great saphenous vein (GSV) and the anterior accessory saphenous vein (AASV) frequently form two ‘saphenous eyes’ in the upper third of thigh on a transverse ultrasound scan. The image clearly distinguishes the GSV from the AASV since the AASV lies anterior and lateral to the GSV over (aligned with) the femoral artery and vein **(Figure 4).**

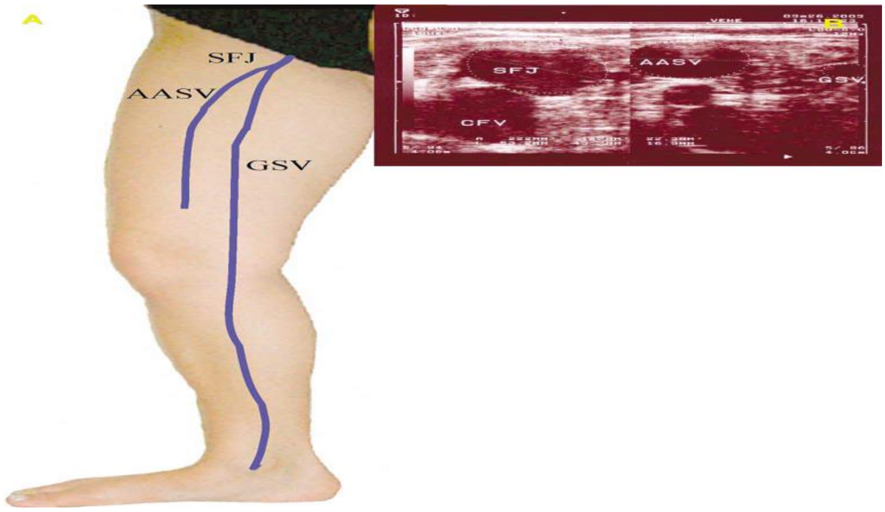

Figure (4): Anterior accessory saphenous vein (AASV) and the alignment sign. (A) The AASV lies laterally to the GSV and these two veins terminate in a common trunk (SFJ). (B) B-mode ultrasound image of the SFJ. The left image shows the commontrunk (SFJ). On the right, 2 cm more distally, the AASV lies laterally to the GSV. Note: the AASVoverlies and alligns with the femoral vessels (femoral vein, superficial femoral artery and deep femoral artery) whilst the GSV passes more medially ***(Cavezzi et al., 2006).***

In some limbs, the alignment sign shows that the only vein visible as an eye is the AASV since the GSV is not visible (absent or hypoplastic) ***(Ricci and Caggiati, 1999).***

C- **Tibio–gastrocnemius angle sign:** The location of the GSV relative to the tibia and medial gastrocnemius muscle below the knee on ultrasound allows it to be distinguished from a tributary of the GSV. The GSV in the knee area is distinguished from nearby veins by its position on a transverse scan in the triangle formed by the tibia, medial gastrocnemius muscle and fascial sheet. This sign identifies the GSV below knee where fascial sheets are often so close to each other that the compartment in which the GSV runs may be difficult to recognise. If the saphenous space is empty, this indicates that the GSV is absent or hypoplastic.

D- **Tributaries:** Tributaries run parallel or beside the track of the associated saphenous vein but are not situated within a saphenous eye on ultrasound imaging. A tributary may be the main axial superficial vein but is not regarded as a saphenous trunk since it lies outside the saphenous compartment ***(Cavezzi et al., 2006).***

Relation of Fascial Compartments to The GSV and Anatomical Variations in The Thigh.

In the thigh, the GSV is contained in its 'saphenous eye'. The fascial compartment is larger and better defined in the thigh than in the leg. Tributaries pierce the superficial layer of fascia to reach the GSV. Transverse ultrasound imaging of the GSV territory in the thigh based on the 'eye' sign has revealed the following anatomical patterns ***(Cavezzi et al., 2006).***

a) A single GSV lying within the saphenous compartment with no large parallel tributary.

b) The GSV in the thigh comprising two parallel veins, both lying within the saphenous compartment for a distance of 3–25cm. (true GSV duplication), which is present in less than 1%.

c) A single GSV lying within the saphenous compartment as well as a large subcutaneous tributary that pierces the superficial fascia to join the GSV at a variable level in the thigh.

d) Two veins, the GSV and AASV, both present in the thigh, located distally in two separate 'saphenous eyes' coming together in a single compartment just before entering the SFJ area In many cases, the AASV is incompetent filling varicosities over the anterior and lateral aspects of the thigh.

e) A single GSV lying within the proximal saphenous compartment as well as a large subcutaneous tributary more distally with nosubstantial vein visible in the saphenous compartment. The distal subcutaneous vein pierces the saphenous fascia at a variable level in the thigh to become the GSV within the fascial compartment.

Relations Between The GSV and Tributaries

The GSV both in the leg and in the thigh is often accompanied by parallel veins of different length that are so large that they may be confused with the GSV itself or considered to be 'double' saphenous veins. Ultrasound imaging