

## Ultrasound Therapy for Varicose Vein

Deepika Princess D., Mohan Jagannath and Biju Shalvin Y.J.<sup>3</sup>

Department of Biomedical Engineering, SMK Fomra Institute of Technology, Chennai, Tamil Nadu, INDIA

Available online at: [www.isca.in](http://www.isca.in), [www.isca.me](http://www.isca.me)

Received 18<sup>th</sup> October 2013, revised 24<sup>th</sup> October 2013, accepted 26<sup>th</sup> November 2013

### Abstract

The vein that carries the deoxygenated blood gets bulged and thick due to defect in their valve which becomes varicose veins. These are most common in legs. These varicose veins are caused by damaged or weak valves of veins that lead to collection of blood in the vein which increase the pressure and cause pain. 19% of the men and 36% of the women are mostly affected by varicose. Mostly the treatment for varicose vein is by invasive methods such as surgery, laser therapy, RF endovenous therapy and sclerotherapy. In this paper, we propose non-invasive therapy for varicose vein using ultrasound therapy. Since it is a non-invasive method, it gives the patient to aesthetic relief from their pain without pain.

**Keywords:** Varicose vein, ultrasound therapy, non-invasive sclerotherapy.

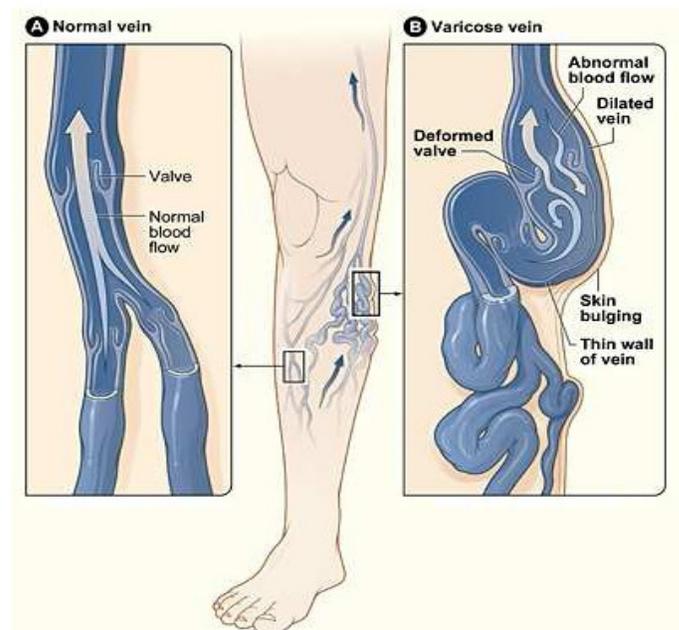
### Introduction

Veins are blood vessels, which return the deoxygenated blood from other parts of the body back to the heart and lungs. When these veins valves that prevents the backflow of blood gets damaged then it becomes thick or enlarged, these are called varicose veins (figure 1). This happens most commonly in the veins of legs and thighs. With rapid development in the modern society, there is a change in lifestyle of people, in everything they depend on the technology and the cases which people are sitting or standing has been increasing. As a result, the awareness for varicose vein which was unfamiliar in few years ago has been gradually increased and the remedy for varicose vein has been studied by non-invasive method<sup>1</sup>.

**Causes of Varicose Vein:** Varicosities occur in veins due to the defective/ damaged valves within. Valves prevent backward flow of blood within the vein. They push the blood in the vein to move towards the heart. It is unclear what causes the valves to work less efficiently. Some experts think inherited problems cause some people to have too few valves or valves that do not functions properly<sup>2</sup>. Some people may be born with abnormalities of the vein wall.

The person with poorly functioning valves when stands up, the blood flow actually reverses and flow downwards, instead of flowing up, towards the heart. When the muscle surrounds the deep veins a build-up pressure occurs. This causes even more blood to flow in the wrong way. Varicose veins can appear following pregnancy, thrombophlebitis, congenital blood vessel weakness, or obesity, but is not limited to these conditions<sup>3</sup>.

**Existing Treatments of Varicose Vein:** The therapies that exist for varicose vein are divided as conservative therapy which includes moderate exercise, recreation, wearing pressure stockings. For acute cases, invasive method traditional surgical treatments are done.



**Figure-1**  
**Normal Vein and Varicose Vein**

Nowadays invasive methods such as Sclerotherapy, RF Endovenous ablation, Laser therapy, stab Avulsion by incision surgery are done.

**Surgery:** Surgery is the traditional treatment for more severe cases. The surgery is based on either vein ligation (tying) or stripping or avulsion (pulling away) of the smaller branches of veins. But this gives more pain to the person and it takes a long time for recovery and it can lead to other injury<sup>4</sup>.

**Sclerotherapy:** This method is by injecting the medicine inside the vein and makes them to shrink. The complications of sclerotherapy includes allergic reactions to the chemical

used, stinging or burning at the various injection sites, inflammation, skin ulcerations, and permanent discoloration of skin<sup>5</sup>. There is a case where stroke occurred due to excess dose of sclerosant.

**Endovascular Laser Therapy:** Endovenous laser therapy is a technique that uses a laser to destroy the vein. It takes about 30-35 min for the procedure and recovery is very fast. For short term it shows no problems. Laser therapy can change in color<sup>6</sup>. And after the treatment also it requires for the patients to wear the pressure stockings.

**RF Endovenous Ablation:** Radiofrequency ablation uses the RF wave for treating the varicose vein. The probe is placed in the vein by the use of ultrasound and once in position, the vein is heated along the entire length. Short term results are excellent using this<sup>7</sup>.

## Methodology

To overcome all the difficulties in the existing method, in this paper we have implemented the method to treat varicose vein using Non-invasive therapy method. Non-invasive therapy method does not need a catheter or any incision that makes a way for the operation; it takes very less time for the procedure as well as for the recovery. It is known that energy based therapies can be applied to tissues throughout the body to achieve numerous therapeutic results. To achieve a desired treatment effect, reaching a temperature to the target tissue of at least about 50°C. For this energy based therapy, we would like to use the ultrasound to treat the varicose vein non-invasively. In ultrasound therapy there are two ways of treatment, one by thermal and another by non thermal-Mechanical<sup>8-11</sup>.

**Thermal Ultrasound Therapy:** Thermal ultrasound therapy uses a more continuous transmission of sound waves. The sound waves cause microscopic vibrations in the deep tissue molecules, increasing heat and friction. The warming effect encourages healing in the soft tissues by increasing the metabolism at the level of the tissue cells.

**Mechanical Ultrasound Therapy:** Mechanical ultrasound therapy uses pulses of sound waves to penetrate tissues. While this still has a minor warming effect on the tissues, it also causes expansion and contraction in the tiny gas bubbles of the soft tissues. This helps to decrease the inflammatory response, reducing tissue swelling and thus decreasing pain. The best way for treating varicose vein non-invasively will be by mechanical ultrasound therapy.

**Cavitation method:** A particularly preferred technique for selectively damaging endothelium cells in a blood vessel is by mechanical ultrasound therapy which is called cavitations method. Cavitations can be defined as the creation or motion of a gas cavity in an acoustic field. It is the oscillatory

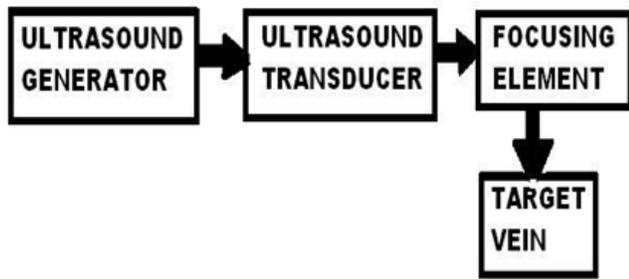
movement of the gas filled bubble. This is by creating the activating agents such as micro bubbles in the tissue. The ultrasound activating agent will only be activated in the focal region of the high intensity focused ultrasound (HIFU) beam; The HIFU is achieved at 25 MHz; the ultrasound activated agent can be introduced into the blood systematically or directly into the blood vessel.

Significantly only a very short burst of HIFU is required to activate such ultrasound activating agents, which means the duty cycle can be made to be sufficiently short duration than the negligible amount of acoustic energy is absorbed by tissue in the focal region of the HIFU beam. The perivascular tissue lies within the focal region of the HIFU beam. So, no or minimal thermal damage will occur to the perivascular tissue, because the HIFU beam will not be energized long enough for the perivascular tissue to absorb enough acoustic energy to damage the perivascular tissue<sup>12</sup>. By changing the frequency and the dimension of the focus can be manipulated the production of bubbles is controlled.

**Working Process:** The vibration energy in acoustic waves emanating from one source of ultrasonic energy is focused beneath the skin to cause localized heating and tissue disruption in and around the varicose segment of the vein, particularly the venous endothelium. The localized tissue destruction is followed by localized fibrosis in and around the dilated portion of the varicose vessel. The ultrasound-induced fibrosis includes thickening and loss of elasticity of the vascular wall. If a sufficiently high dosage of ultrasound energy is delivered to the vein, the varicose portion of the vessel will be obliterated, providing a therapeutic result similar to that obtained by injection sclerotherapy or vein stripping. Alternatively, focused ultrasound may be used to induce fibrosis in the tissue overlying the varicose vessel thereby providing a relatively inelastic barrier which resists unsightly deformation of the skin overlying the varicose vein due to venous dilation.

When using ultrasound to treat varicose veins in accordance with the method of the present invention, it is preferable to administer focused ultrasound energy to the varicose vein in its entirety. The focused ultrasound is delivered to the vein in a dose sufficient to cause disruption of the venous endothelium therein. The targeted portion of the vein (i.e., the portion of the varicose vein receiving focused ultrasound treatment) is then compressed by means of a compression bandage.

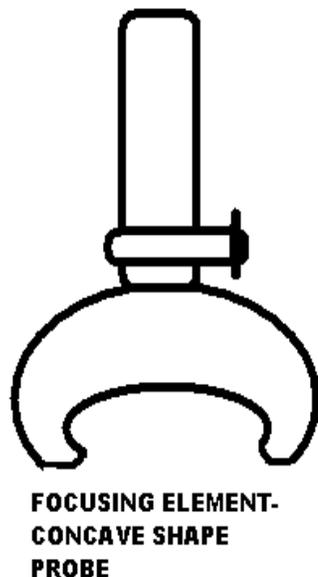
As the damaged endothelium heals, it is accompanied by a proliferation of cellular tissue which at least partially occludes the venous lumen thereby reducing or eliminating blood flow there through, and dilation thereof. If the endothelium is sufficiently damaged during treatment, the endothelial tissue may fuse, causing total obstruction of the venous lumen.



**Figure-2**  
**Block diagram of ultrasound therapy**

An ultrasonic transducer is in electrical communication with an ultrasonic generator. The ultrasonic generator is operable for providing an electrical output signal having a frequency between 1 MHz and 100MHz, and most preferably around 25MHz. The ultrasonic transducer element, piezoelectric crystalline material or electrostrictive device, receives the electrical output signal from the generator and produces mechanical vibrations having a frequency which is synchronous with the electrical output signal. The ultrasonic generator (figure 2) is energized by means of a power source. The ultrasonic transducer is in vibrational communication with a first side of a focusing element, the focusing element has a concave second side which is in vibrational communication with the tissue overlying and including the varicose vein.

A layer of an impedance matching material, such as a fluid or a gel, wherein the velocity of ultrasound therein is similar to the velocity of the ultrasound in body tissue at the operating frequency, may be interposed between the concave second surface of the ultrasonic transducer and the epidermis to optimize power delivery to the targeted tissue.

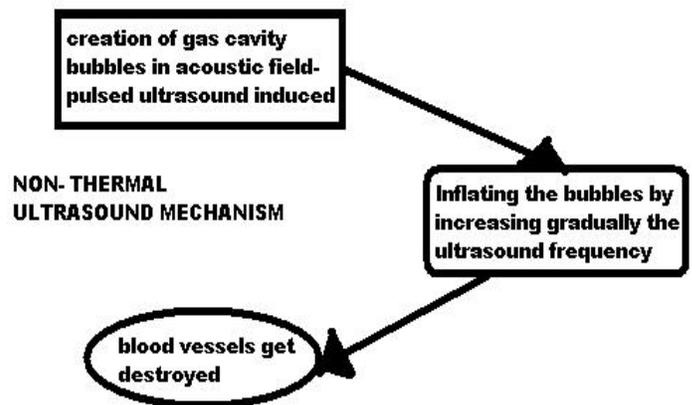


**Figure-3**  
**Concave shape ultrasound probe (focusing element)**

The focusing element we propose is of concave shape, (figure 3) it makes it easy to focus exactly the varicose vein. This probe has a control to adjust the size of the focusing side. The frequency of the ultrasound to be delivered is the major factor of controlling the concave size. First an ultrasound scan has to be taken and the depth level of the varicose vein from the vein has to be determined and then the frequency deliverance is marked.

**Results and Discussion**

When the ultrasound waves at frequency 25MHz is given to part to be treated, Small gas cavity bubbles are created. These bubbles contract (figure 4) and expand as the ultrasound is delivered in pulsed form. These Micro bubbles grow in the blood vessel and at a point it will burst open, damaging the vessel. The vein will be devoid of blood vessels, thus it will get stuck together reducing the size of the vein.



**Figure-4**  
**Mechanism of Therapy**

The result may be similar to the sclerotherapy operated varicose vein. Thus this method of treating varicose vein will relieve the patient from their ache non-invasively, and for cosmetic appearance too, it plays a major role as it does produce scar or rashes. Thus there is no damage to the skin appearance. Since it is non-invasive it relieves patient’s pain without pain.

**Conclusion**

It is known that energy based therapies can be applied to tissue throughout the body to achieve numerous therapeutic result. By using Ultrasound, we can treat varicose vein non-invasively. Non- thermal method of ultrasound for varicose vein therapy is more efficient way of treatment. It’s a therapy done outer over the tissue. The Tissue disruption can be done by non- thermal therapy. The mechanical therapy that promotes acoustic waves in a narrow beam can damage the venous endothelium without adjacent perivascular tissue. And the required time is less than that of other therapies so far existing and it does not induce any side effects as that of other therapies and it is more comfortable for patients as it relieves

pain without pain and provides more aesthetic result and there is no damage to the skins too.

## References

1. Kim W., Woo T., Yoo M., Cho J., Kwon D., Cung Y. and Cheon C., A new method for remedy of varicose vein using Horn Antenna, *Antennas and Propagation Society International Symposium (APSURSI), IEEE*, 978-981 (2010)
2. Bradbury A., Evans C et al., What are the Symptoms of Varicose Veins?', Edinburgh vein study cross sectional population survey, *British Medical Journal*, **318(7180)**, 353-356 (1999)
3. Laddha G.P., Vidyasagar G., Bavaskar S.R., Mahale V. and Rathod M., Varicose Vein: recent complications in humans, *Journal of Chemical, Biological and Physical Sciences*, **2(2)**, 885-895 (2010)
4. Canonico S., Luminello F et al., Long-term recurrence and nerve injury after total and partial stripping of the great saphenous vein by external phleboextractor, *Vascular Surgery*, **34(2)**, 163-166 (2000)
5. Darvall K.A.L., Bate G.R., Adam D.J. and Bradbury A.W., Recovery, analgesia use, and return to normal activities after ultrasound-guided foam sclerotherapy compared with conventional surgery for varicose vein, *Br J Surg.*, **96**, 1262-1267 (2009)
6. Puggioni A., Kalra M., Carmo M., Mozes G. and Gloviczki P., Endovenous laser therapy and radiofrequency ablation of the great saphenous vein, Analysis of early efficacy and complications, *Journal of vascular surgery*, **42**, 488-493 (2005)
7. Almeida J.I., Kaufman J., Gockeritz O et al., Radiofrequency endovenous Closure FAST versus laser ablation for the treatment of great saphenous reflux, a multicenter, single-blinded, randomized study (RECOVERY study), *J Vasc Interv Radiol.*, **20**, 752-759 (2009)
8. Johns L.D., Non-thermal Effects of Therapeutic ultrasound, the frequency Resonance Hypothesis, *Journal of Athletic Training*, **37(3)**, 293-299 (2002)
9. Michlovitz S.L., Thermal Agents in Rehabilitation, FA Davis Co, Philadelphia, 141-176 (1986)
10. Baker K.G., Robertson V.J. and Duck F.A., A Review of Therapeutic Ultrasound: Biophysical Effects, PTJ, *Journal of the American Physical Therapy Association*, **81**, 1351-1358 (2001)
11. Speed C.A., Therapeutic ultrasound in soft tissue lesions, *Rheumatology*, **40**, 1331-1336 (2001)
12. Henderson P.W., Lewis G.K., Shaikh N., Sohn A., Weinstein A.L., Olbricht W.L. and Spector J.A., A portable high intensity focused ultrasound device for non-invasive venous ablation, *Journal of Vascular surgery*, **51**, 707-711 (2010)