Portable Therapeutic Device for Venous Insufficiency of Lower Limb

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***Abstract*— There are millions of people in this world suffering from venous diseases such as varicose veins, Deep Vein Thrombosis (DVT), phlebitis etc which ultimately results in chronic venous insufficiency. The existing interventional treatment techniques are painful and requires more time for recovery. Current compression devices, known as Intermittent Pneumatic Compression devices (IPC), use air pressure to compress limbs. These devices are bulky and causes discomfort to patients .The proposed system includes two modes of therapy such as compression and electromagnetic therapy which is portable and cost effective. The compression system provides sequential compression using microcontroller based preset pressure sensing system. The electromagnetic therapy provides heating effect to restore the blood flow. A case study was conducted to analyze the efficiency of this portable device.**

I. Introduction

There are millions of people in this world suffering from venous diseases such as varicose veins, Deep Vein Thrombosis (DVT), phlebitis etc which ultimately results in chronic venous insufficiency. The existing interventional treatment techniques include Sclerotherapy, Ablative therapy with Endovenous, Radiofrequency and Laser, venous phlebotomy, Subfascial Endoscopic perforator surgery which are painful and require more time for recovery. In recent years several advancements have taken place in non invasive therapeutic procedures. Among these procedures, compression therapy has proven to be efficient for treating venous diseases. In this work, portable and cost effective non invasive therapeutic system providing two modes of therapy namely compression for calf veins and electromagnetic therapy has been implemented. The underlying mechanism in compression therapy can be well understood with the knowledge of physiology of venous valves.

II. Physiology of Venous Valves

The veins in the leg are divided into superficial, perforator and deep veins. The veins contain valves which regulate the blood flow. These valves comprise two thin flaps of tissue attached to vein walls. When the leg muscles contract blood is pushed along the vein from distal to proximal, that is from the leg towards the heart, and the flow of blood pushes the flaps to the side and opens the valve. When the leg muscles relax, gravity causes the blood to flow backwards down the vein. This closes the valve and prevents the blood moving back into the next section of vein. When the leg muscles contract again, the pressure on the blood in the vein opens the valves to allow the blood flow towards heart. Chronic Venous insufficiency occurs when the valves of the veins do not function properly. Venous failure may occur due to weakening of valves as a result of conditions such as varicose veins, Deep Vein Thrombosis (DVT), trauma or venous obstruction. Figure1.1 shows the mechanism of action of venous valves.

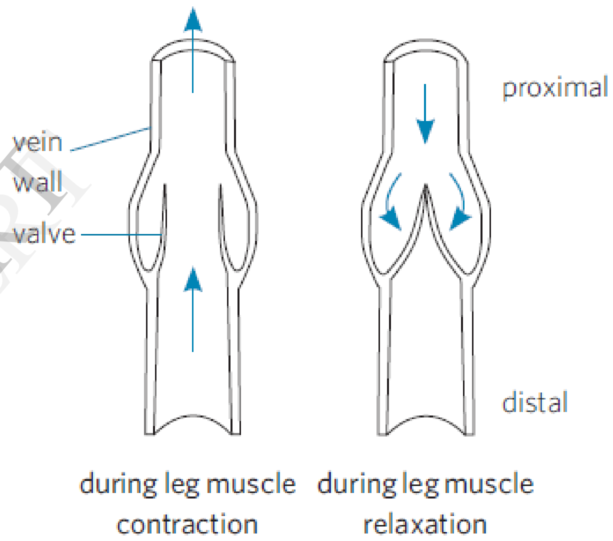

Figure 1.1:Mechanism of action of venous valves

III. Compression Therapy

There are different types of compression such as uniform, gradient, concurrent and sequential compression. Sequential compression therapy has found to be more effective than other methods and hence this technique is adopted in this work. The stockings used to provide compression is made of nylon material .The outer covering of bag is provided with Velcro which facilitates wrapping of stockings around the patient limb. The stockings is designed such that it has two separate chambers for providing sequential compression . Air bladder with tubing is provided separately for the two chambers to facilitate the inflow of air. The release of air occurs through the same tubing connected to the control unit which releases air using an outlet solenoid valve. The ideal pressure required for calf compression is found to be 40 mm Hg. The working of this unit is as follows. When a preset pressure of about 40 mm of Hg is applied to one of the chambers, blood vessels in the region of compression are squeezed which forces the blood flow through the vein. Now the other chamber is inflated with the first chamber containing no air. This process is repeated several times to achieve a considerable amount of compression. Figure 2.1 shows the block diagram of the proposed system.

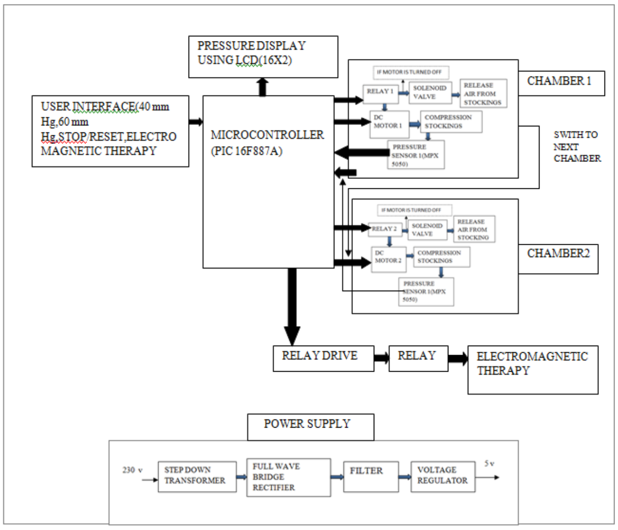

Figure 3.1: Block diagram of the therapeutic device

A. Control unit

The air pressure required for compression is provided by a DC motor which requires a supply of 5 V and produces maximum of 160 rpm. The motor operation is controlled by PIC16F887A microcontroller. A sensor unit of type MPX 5050 is connected to motor to sense the air pressure in the stockings. The pressure required for compression is measured in terms of voltage by the sensor. Hence it was calculated that for 40 mm Hg, the optimum voltage is 3V and for 60 mm Hg it is around 3.5 V. The microcontroller unit has a sophisticated architecture provided with five different ports namely A, B, C, D and E which permits interfacing of various peripherals with the control unit. The air inflation and release mechanism occurs as follows. When the switch connected to the control unit is turned on, the motor is made to rotate. When the pressure in one of the chambers reaches 40 mm Hg or when 3V is reached at specific I/O port of the controller, the relay unit corresponding to this chamber is turned off and the air in this chamber is released through a solenoid valve connected to the Two relay units are made to work alternatively to provide sequential compression in the two chambers. The pressure required for patients were set at two values using switches connected to the controller. Around 40mm Hg was chosen for patients with mild disease condition and a maximum of 60 mm Hg was chosen for patients of severe disease condition such as solid Lymphedema.

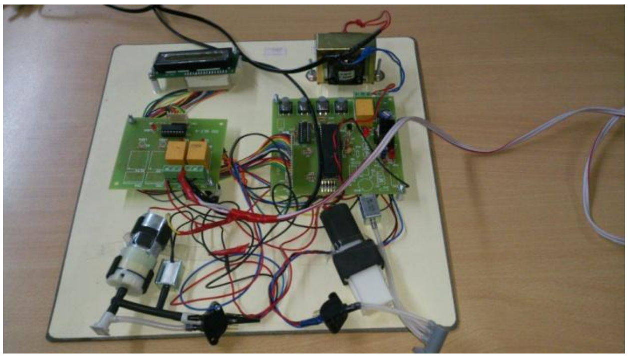

Figure 2.2: Control unit of Compression Therapy unit

IV. ELECTROMAGNETIC THERAPY

It is based on the principle of mutual induction. It makes use of a metal disk with coils wound around. The principle of mutual induction is that when an electric current is applied to one of the coils an induced current is produced in the other one. In this application, body surface acts as another coil. Thus, when a metal disk is placed on the region of body and electric current is applied on it, the mutual induction causes electric current to transfer to the body surface. This electric current heats the region of body. This heating effect dilates the blood vessels resulting in increase blood flow. In venous diseases such as lymphedema, the fluid accumulation in the lymphatic vessels obstructs the blood flow to the tissues. Figure 2.3 shows the electromagnetic therapy unit.

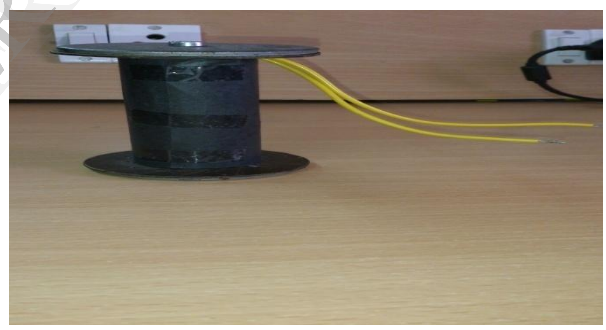

Figure 4.1: Electromagnetic Therapy unit

V. RESULT AND DISCUSSION

The efficiency of compression therapy was analyzed by conducting case study on three patients with various physiological conditions resulting in chronic venous insufficiency. The study was done under the guidance of Dr.P.Govindaraj, Consultant vascular surgeon in a private medical centre. Initially, the device was tested in two patients to ensure that the device is not causing harm to patients. The first patient chosen for study was a 67 year old male with lymphedema in the ankle region and with moderate level of swelling in the calf region. The size of region below calf was 27.8cm and 34 cm in the calf region before therapy. After therapy for 20 minutes, there was reduction in size and became 26cm in the lower part and 33 cm in the calf region. The right leg of patient before and after applying therapy are shown in figure 5.1 and 5.2.

Figure 5.1:Patient 1 limb before applying therapy

The second patient was a 81 year old male with swelling in both legs in the calf region. Therapy was applied for 20 minutes each for both legs. Before applying therapy right leg calf region was measuring 35 cm and right leg was measuring 31.5 cm. After therapy, right leg measured 34cm and left leg measured 31 cm.The patient felt comfortable to walk after therapy.Figure 5.3 and 5.4 shows the therapy application for right leg.

Figure 5.2 :Patient 2 right leg before therapy

VI. CONCLUSION AND FUTURE ADVANCEMENTS

The case study is in progress and the efficiency has to be evaluated in more patients of different conditions. Future advancements include setting different pressure ranges for compression therapy and incorporating more compression chambers for providing therapy to ankle and thigh region.

VII. REFERENCES

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