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How to rehabilitate a vascular patient?

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Introduction

The prevalence and incidence of vascular diseases have been studied, and are common among older men and women, affecting 20% to 30% related to Occlusive Peripheral Arterial Disease (OPAD), and from 25% to 50% related to Chronic Venous Insufficiency (CVI) in general medicine practice [(1- 11).]

The goal of therapy in patients with vascular disease is to improve their functional status, and any program to be designed begins with a systematic evaluation of the exercise tolerance and venous hypertension relative measurements of the candidate that will serve as support for an individual exercise program to help achieve the goal projected.

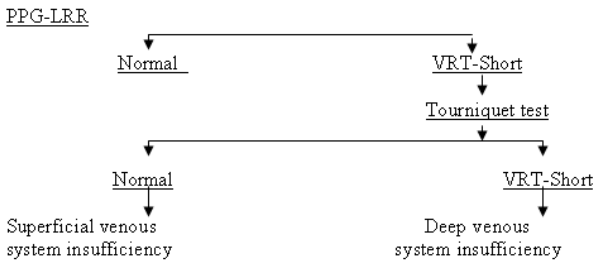
Appropriate studies to objectively determine the severities of the functional impairment of these diseases are made at the Vascular Laboratory.

A high degree of linear relationship was found in our practice [(12)] as well as other studies [(13, 14)] for PPG-LRR-VRT and Refilling time measured by means of Ambulatory Venous Pressure, which became the hemodynamic gold standard used in the development of noninvasive methods for screening of patients with CVI [(9)].

The first study to be performed to the patient will be a sitting position Photoplethysmography (PPG) type Light Reflection Rheography (LRR) with the complete diagnostic algorithm (Figure 1). If the Venous Refilling Time (VRT) is
normal, the study is concluded; if it is abnormally short (<25 seconds), the test will be repeated after a 2.5 centimeter wide cuff tourniquet is positioned above the knee, below the knee, above the ankle or any place where the technician requires to occlude the superficial vein return of the blood. Normalization of the VRT after occlusion of the superficial veins suggests that reflux is confined to the superficial venous system.

If the PPG-LRR study is abnormal, an Eco-Doppler scanning will be used for evaluation of obstruction, reflux or both and their anatomic extent just for diagnostic purpose.

Figure 1. PPG-LRR Algorithm of work. Reproduced from Maduro-Maytin, CL [(12)]



Simultaneously a supine and standing position venous pressure at rest will be measured by Doppler. Values larger than 20 mmHg, and between 20 mmHg and 50mmHg, have been determined at our Vascular Laboratory as normal values and normal range values for those measurements, respectively.

At this moment, a non weight bearing goniometric measurement of the active Range of Motion (ROM) of the ankle joint is obtained. During measurement, the foot is hold by a plantar platform as a goniometric

mobile arm to control entire forefoot and prevent any unacceptable position. An image of the foot with landmarks painted on reference points is then obtained with a digital camera. Images taken at resting, maximal Dorsiflexion (DF) and Extension (E) (plantar flexion) positions with the patient supine on the worktable and legs straight are also taken. These imagines are then sent to a computer that processes them with a software program that provides measurements of angles.

It is also useful to get the hard copy of the data obtained. Such printed data obtained by goniometry is important to:

- Establish a diagnosis
- Determine and **quantify** a dysfunction.
- Develop therapeutic objectives and goals
- Look at the effectiveness of specific therapeutic techniques
- Establish and modify protocols for treatment
- Give information to the patient as it can **encourage** them to continue protocols
- Prove treatment effectiveness and objective measurements of improvement for insurance purposes

Following the PPG-LRR and Venous Doppler pressure studies and the Eco-Doppler (if needed) and goniometric ROM studies, the Ankle-Brachial Index (ABI) is obtained by dividing the posterior tibial systolic pressure found at rest with a pocket Doppler, by the brachial systolic blood pressure. It will include segmental pressures obtained at high thigh, eight centimeters above the knee, eight centimeters below the knee and above the ankle joint. The normal range for ABI is 0.9 to 1.2. Most patients with intermittent claudication will have an ABI of 0.4 to 0.8 and an ABI less than 0.3 will indicate a critical lower limb ischemia [15].

After the arterial pressure measurements by Doppler have been achieved at rest, a classic standardized treadmill test (Constant-Load Exercise Testing) will be done allowing the patient walk on the treadmill band with a speed of 2 miles/hr during five minutes and 10% of inclination. The technician will obtain the distance of the beginning of the pain, intensity and character of the pain and its evolution until the final distance. The test is terminated when the patient reaches a maximal level of claudication pain (absolute claudication distance).

Rehabilitation of patients with arterial disease

Supervised exercise programs have demonstrated to improve the absolute walking distance and heal venous (vascular) ulcers that enable the patients to become more functionally independent [16-21].

The treatment is done in four phases and the main exercise program consists in a walking program that the patient does on the treadmill band with a gradual increase of the speed, inclination of the band and time exposure.

Many protocols have been used by different groups [18-20]. We use a protocol consisting of a nine stage program (Table 1).

Table 1. Nine stage program protocol after Hiatt, WR; et al [22]

Stage	Speed (mph)	Grade of Inc. (%)	Time (min)	Distance (m)
I	1.0	0	2	48
II	1.5	0	3	120
III	2.0	0	4	208
IV	2.0	10	7	368
V	2.0	10	10	528
VI	2.0	10	13	688
VII	2.0	10	16	848
VIII	2.0	10	19	1008
IX	2.0	12	22	1168

mph: miles per hour; min: minutes; m: meters.

The patient is stationary at the beginning of the program and the speed is then adjusted in 1/10 mph increments until the maximum planned speed is reached. The grade of inclination and time programmed for each session is given as shown in the stage progress.

During each session, the Vascular Rehabilitation staff (physical therapist, nurse and physician) will monitor the heart rate and blood pressure during the exercise session and will encourage the patient for the best performance.

After each stage is done, a five minute rest, or whatever time is needed to eliminate the pain, is given to the patient and the exercise re-starts at the next stage. The complete time for each session will be of forty five minutes to one hour each day.

The treadmill band consist of an approximate 50 cm x 150 cm, low profile, Teflon-impregnated running deck, with a low step-up and a shock-absorbing surface to reduce stress and trauma to the lower back and lower extremities. It has handrails that can be extended for safety and comfort.

Rehabilitation of patients with venous disease

The normal functioning of the venous pump of the calf is the ability to keep the venous outflow from the lower leg equal to the arterial inflow during exercise, without undue dilatation of the vein of the lower leg with low

pressure in the input area, mainly in the ankle region. During the walking cycle, DF produces a significant increase of pressure in the Anterior Compartment of the leg (AC); meanwhile E causes an increase in the pressure of the Posterior Compartment (PC). During each movement, a highly significant boost in the pressure occurs in a single compartment [23].

The Calf Muscle Venous Pump expels the blood coming from the arterial inflow, acting with a diastolic period and a systolic period for the contraction of the muscles. This begins with the inside AC compression and the peak DF torque occurs in the late terminal stance as the E torque is reduced to zero. As the ankle joint moves in a single plane, all the controlling muscles function either as dorsiflexors or plantar flexor (extensors).

Torque, by definition, is a twisting effort applied to an object that tends to make a turn about its axis of rotation. The magnitude of torque is equal to the magnitude of the applied force multiplied by the distance between the object's axis of rotation and the point where the force is applied. In many ways torque is the rotational analogue to force [24].

The hemodynamic of the lower leg's venous return depends then on several factors:

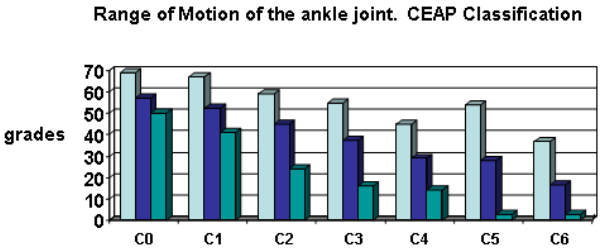
Efficacy = AC torque + Foot squeeze + PC torque + Sequential Mode + Healthy valves

The efficacy is equivalent to the management of the load (Venous Volume) by the torque (Strength of the muscle and maximal range motion of the ankle joint) in sequential mode (including prime of the pump) with healthy valves. Hence, improving one or all of the factors, will improve the efficacy of the pump.

It has been demonstrated that the severity of the reflux, obstruction or both in venous disease is not enough to produce Chronic Venous Insufficiency (CVI) [25] , and it has been demonstrated as well that the ROM decreases significantly with increasing C class [CEAP classification for CVI patients [9]] (Figure 2). The more symptomatic the CVI patient is, the smaller the ROM of the ankle joint is [12, 24, 26, 27]. Similarly, increasing the ROM as a result of an exercise program increases the performance of the CMVP [28, 29, 30]. Hence, the key for the rehabilitation of such kind of patients will be the evaluation and rehabilitation of the ROM of the ankle joint.

Ankle joint movement is limited by means of "soft-parts" and "hard-parts". Tension of the capsule and ligaments, and the hypertonic resistance of muscle are soft-parts that can limit the E and DF of the ankle joint causing a permanent flexion. Hard-parts may include anatomic bony factors that contact with the later margin of the tibial surface and, although rare, fractures of the lateral tubercle. In this situation, a radiological study of the foot in front and lateral views has to be considered to look for these bony factors, and it can also be considered if the pain as well as the edema limits the motion of a joint.

Figure 2. Inclusion of the Range of Motion (ROM) of the ankle joint as part of the evaluation of patients with Chronic Venous Insufficiency. From Maduro-Maytin, CL [31]



The rehabilitation of the ROM of the ankle joint should be done in a step wise manner and mainly with exercises and a variety of treatment modalities that can help such as heat, Hydro-aquatic therapy, ultrasound and electricity.

Range of Motion Exercises

Andersen has demonstrated that a change of 1.5 cm in the axis of rotation of the ankle results in a change of the peak torque by 8.3% for an extension movement [32]. Hence, any small change in one factor of the ankle movement could cause a bigger hemodynamic effect. It is important then to start with non-weight bearing exercises, moving to resisted exercises, and then weight bearing activities to achieve an effective rehabilitation program.

1. Exercises to increase ankle's ROM

a. The passive and active - non weight bearing motion of the foot

The motion of the foot can be done by a Physical Therapist (PT), instrumentally, or by the patient. Any of these modalities will have a goal, a program based on a ROM assessment, to avoid pain.

All exercises will be performed on the worktable with the leg fully extended and the knee straight, the same way as the ROM data achieved by goniometry was obtained.

The **Dorsiflexion-Extension (Plantar flexion)** is done as follows:

I. The foot is pulled back or pushed forward (while keeping knees straight) by the PT, the machine, or the patient. The motion will continue back or forward until discomfort is felt.

II. This position is maintained during 15 seconds.

III. Return to the initial neutral - rest position.
IV. Repeat steps 1 to 3 ten times

2. Exercises to increase ankle's muscles strength

a. Isometric Strengthening Exercises

The exercise will be performed on the worktable with the leg fully extended and the knee straight. The foot will be pushing outward (Extensors or Plantar flexors muscles) or pulling inward (Dorsiflexors muscles) a fixed object. It will cause a contraction of the muscles and the object will not be moved.

b. Resisted Strengthening Exercises

Each exercise will be performed with an elastic band or a pulley with weight providing resistance to the movement. Special machines can be used for this purpose [33, 34].

The **Dorsiflexion-Extension (Plantar flexion)** for both types of exercises is done as follows:

I. The patient pulls his/her foot back or pushes his/her foot forward against the resistance of the elastic band or the pulley with weight by moving the ankle joint while keeping knees straight.
II. Return to initial neutral - rest position.
III. The exercise is repeated until the patient gets tired and then he/she gets a one minute rest.
IV. Repeat steps 1 to 3 ten times.
V. If the patient is able to lift or push a weight 10 times, the weight is increased for the next session.

Other Physical Therapies modalities

1. Thermotherapy

Heat provides several important benefits: it decreases pain, relaxes tight muscles caused by tension or spasms, and causes vasodilatation of the blood vessels which increase circulation in the area. This promotes tissue relaxation and therefore is useful in the period previous to the increase ankle's ROM exercises.

Table 2. The modalities of Thermotherapy Agents.

Mechanism	Conduction	Convection	Conversion
Superficial	• Hot packs • Paraphine	• Hydrotherapy	• Infrared
Deep			• Microwave • Ultrasound

2. Aquatic therapy

Aquatic or pool therapy consists of an exercise program that is performed in the water, using the physical properties of water to assist the patient on exercise performance. The water's viscosity provides an excellent source of resistance that can be easily incorporated into an aquatic therapy exercise program. This resistance allows for muscle strengthening without the need of weights, and using resistance coupled with the water's buoyancy allows a person to strengthen muscle groups with decreased joint stress that cannot be experienced on land, since it is easier and less painful to perform exercises with smaller amounts of joint stress. The hydrostatic pressure also assists in decreasing joint and soft tissue swelling, and the warmth of the water experience during aquatic therapy assists in relaxing muscles and dilates vessels, increasing blood flow to injured areas.

3. Ultrasound

This is a modality used by a PT that uses high or low frequency sound waves that are transmitted to the surrounding tissue and vasculature. These waves penetrate the muscles to cause deep tissue/muscle warming, which promotes tissue relaxation. Therefore, it is useful in treating muscle tightness and spasms, and the warming effect of the sound waves also causes vessel vasodilatation and increase circulation to the area. The PT can also adjust the frequency on the machine to use waves that will decrease inflammation.

4. Electrical Stimulation of Muscles and Transcutaneous Electrical Nerve Stimulation

a. Electrical Stimulation of Muscles (ESM)

ESM uses electrical current to generate a single or a group of muscles contraction by placing electrodes on the skin in various locations and engaging the appropriate muscle fibers. Contracting the muscle via electrical stimulation also helps to strengthen the affected muscle, and the PT can change the current setting to allow for an intense or gentle muscle contraction. Faghri and his group found that the highest Ejected Volume (EV) in their series results from combining voluntary contraction of the calf by Tiptoe (TT) movement and ESM of the calf, including the muscle Tibialis anterior(35). In this study, the addition of ESM to voluntary contraction of the calf by TT movement caused a 21% increase in EV and a significantly high Ejection Fraction of 73%. They also compared the voluntary contraction of the calf (TT), ESM of the calf (Gastrocnemius, Soleus and Tibialis anterioris), and the ESM and voluntary contraction combined, and concluded that a physiological movement of the ankle joint, in order to achieve optimum CMVP function, should include DF movement as part of normal walking cycle. Besides that with increasing muscle strength, the contraction of the muscle also promotes blood supply to the area.

b. Transcutaneous Electrical Nerve Stimulation (TENS)

TENS consists of an electrical signal that disrupts the pain signal that is being sent from the affected area to the surrounding nerves. By breaking this signal, the patient experiences less pain. It is usually a small battery operated machine from which an electrical

current is sent through the electrodes applied to the affected area and a tingling sensation is felt in the underlying skin and muscle.

5. Infrared light irradiation

It has been demonstrated that heat stimulus by infrared light irradiation improves the range of joint motion, because the flexibility of soft-part tissues, such as a muscle or a tendon, is improved by increasing the muscle temperature [(36)].

Rehabilitation of patients with lymphedema

The lymphedema rehabilitation unit would be designed to educate, assist, rehabilitee and support patients suffering from lymphedema, even though these patients will be less in number compared to the rest of the vascular patients. On lymphedema patients we will go behind the same approach for prevention and treatment as the rest, including getting to know the disease and the risk factors, providing education, and when considered necessary, physical therapy treatment.

The unit will implement the latest approach of rehabilitation to help patients improve their quality of life and ability to manage their lymphedema condition following the advices of the Lymphedema treatment program of the Academy of Lymphatic Studies. Fl. USA[(37)] .

Complex Decongestive Physical Therapy (CDPT)

The CDPT components are the Manual Lymph Drainage (MLD), exercises, bandages and skin care, and there are two phases for it:

1. First phase (intensive):

The primary goal is to decongest the limb completely. The MLD is performed daily, ideally in the clinic, until the goal is achieved. After the MLD is done, short stretch bandages are applied.

2. Second phase (improvement and/or maintenance):

The MLD is performed as needed. The main goal is to prevent the re-accumulation of evacuated lymph and the lymphatic channels are kept open and active; this way the fibrosis will be treated, ROM increased, and the compression treatment will continue. The patient has to wear a compression garment every day, 24 hours a day and supplementary exercises must be performed every day. Skin hygiene and medical monitoring are also needed, and the awareness of the patient's compliance is very important in this phase.

Manual Lymph Drainage (MLD) technique

The MLD is a gentle manual treatment technique which improves the activity of the lymph vessels with mild mechanical stimuli to re-route the lymph flow around blocked areas into more centrally located lymph vessels, in order to drain into the venous system. The MLD main goal is to relieve the swelling by increasing the lymphangion intrinsic movements, relieve the pain, increase the parasympathetic neural system effects, create a relaxing effect, and increase lymphatic loads transportation.

Therapeutic Exercises for lymphedema patients

The exercises for lymphedema patients will be basically the same as those exercises performed by the patient with vascular venous disease. The patient will be wearing the compression bandage or garment to improve the lymphokinetic effects of the joint muscle pumps.

Contraction of the muscles is an important part of the treatment as it stimulates the lymphatic system, which greatly assists the lymph drainage and thus helps to reduce the swelling in the limbs. In addition, the patient will always be encouraged to walk with a normal gait and limping or dragging the affected leg should be avoided. If a treadmill band is used, keep it on a low setting mode to avoid tension or pain.

Compression Bandages

When bandaging, a short stretch bandage is used. Bandages increase tissue pressure and decrease ultra filtration. It improves lymphatic and venous blood flow and improves muscle pump function.

Skin care

Infection of the lower limbs is very common and is a serious complication of lymphedema. Patients will be assisted to take care of their skin and nails to avoid infection and the therapy will not proceed until all infections, either bacterial or fungal are under control.

Other methods

Pulsed ultrasound, dry sauna with infrared rays and electricity (AC current: 950 Hz to 22 V) have been proposed. However, we do not have any previous experience with any of them.

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