

## CHAPTER 11 PHYSIOLOGY OF VENOUS INSUFFICIENCY

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### Introduction

**Chronic venous insufficiency** is a broad term which is not well defined. The term is used by doctors for many different venous problems. No matter what term you want to use, chronic venous insufficiency or **chronic venous disease** is seen as **leg swelling**, skin darkening (**hyperpigmentation**), skin thickening (**lipodermatosclerosis**), and when severe enough can cause an **ulcer** (sores or wound) most often seen near the ankle. Normal venous blood movement (circulation) depends on a normal central pump (the heart), a **venous pressure gradient**, a normal **calf muscle pump**, and normal **vein** structures with intact **valves**.

For **chronic venous disease** causing chronic skin changes, the latter two (a normal **calf pump** and intact venous structure) are likely the most important. The leg has 3 muscular pumps (muscle groups that can push blood out of your leg toward the heart): the **foot pump**, the **calf muscle pump**, and the thigh pump. The foot pump “primes” the system or fills the lower leg **veins**, the **calf muscle pump** generates most of the push to drive the blood out of the lower leg and through the **veins** (blood vessels carrying blood out of the leg and toward the heart), and the thigh pump is the least important providing support to the rest of the venous piping. In a normal system, when the **calf muscle** contracts or moves it produces a lot of force which pushes blood through the **veins**, up against gravity and back towards the heart. When the muscle relaxes and the veins lying within open up, it creates a gradient (less pressure within in comparison to the other **veins**) which draws the blood from the **superficial system** into the **deep system** to help with venous blood movement. In a normal person, an intact **calf muscle pump** is efficient – forcing about 70% of the blood out of the calf as we walk. If the **calf muscle pump** and venous piping and **valves** lying within are not working, **chronic venous insufficiency** becomes a problem for the patient.

### Chronic Venous Insufficiency

Two other major contributors to **venous insufficiency** are **venous reflux** and **venous obstruction**. There are three different regions (locations) of **veins** (the piping or tubes within lies the blood) within the leg – the **superficial veins**, the **deep veins** lying within the muscles, and the **perforating veins** which connect the **deep** and **superficial veins**. The **valves** are made of two very thin flaps of tissue which meet in the middle to stop the backward flow of blood within the **veins**. If the **valves** have been injured or are not normal, **venous incompetence** or **reflux** can happen allowing the blood to **reflux** or go back down the veins into the legs (**Figure 1**). **Venous reflux** may occur in the **superficial veins**, the **deep veins** or the **perforating veins**. If the inside of the **veins** (the lumen) is

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scarred or blocked (**venous obstruction**), this will prevent the blood from getting out of the leg (prevent normal **venous outflow**). Any or all of these problems can cause **venous hypertension** or elevated pressures within the **veins** which can push fluid and protein out of the **vein** and into the lower leg tissues which then cause skin and tissue changes associated with **chronic venous insufficiency**.

**Deep venous reflux** or **obstruction** often is seen after a **blood clot** in the lower leg (**deep vein thrombosis**). **Blood clots** may occur whenever there is an injury or trauma to a **vein**, poor blood flow or slow blood flow in a **vein** (decreased venous blood circulation), or when the blood clotting is too active. Once a **blood clot** is formed the body has agents (proteins) which work to breakdown the **blood clot** (called **thrombolysis**) and clean up and restore the **vein** to normal. In about 50% of cases, this happens over about a 6 month period of time. In many people, the **blood clot** is never fully cleaned up and there will remain scarring and damage of the inside of the **vein**. In some cases, there is just a small amount of damage seen as ‘webs’ left in the **vein** while in other cases there may be a large amount of damage seen as complete scarring and loss of the entire inside of the **vein** causing blockage of blood movement (**obstruction**). The body works to make up for this blockage by opening up smaller **veins** (collateral **veins**) for the blood to move around the obstruction or by making holes in the **vein** which still allow some blood movement in the damaged **vein**. In common terms, if you compare the major **veins** to the highways and the collaterals channels to the side streets – blood still can flow out of the leg and back to the heart but the side streets are never as good with moving the cars as the highways would be. Therefore the amount of the **obstruction** (blockage) and the efficiency of the collaterals (side streets) determine the impact of the **blood clot** on **venous return**.

Along with scarring of the **veins**, a blood clot may injure the **valves** (two leaflets lying in the **vein** which shut to stop the backward flow of blood) causing **incompetence** and **deep venous reflux** or back flow (**Figure 1**). This will allow the blood to go backward in the **vein** and down the leg rather than up to the heart. In most cases, a strong **calf muscle pump** can make up for this unusual blood flow. However, if the **calf muscle pump** is not working or if there is damage to the **perforating veins**, this unusual backward flow of blood can cause **venous hypertension** or elevated pressures in the lower leg.

When there is **obstruction** or **reflux** following a **blood clot**, it is called the **post-thrombotic syndrome**. Up to 70% of patients may have signs and symptoms of **post-thrombotic syndrome** 7-10 years after a **blood clot**. The changes of **post-thrombotic syndrome** may range from mild **swelling** to severe **skin changes**. In the worst cases, this can cause open wounds known as venous stasis **ulcers**.

**Superficial venous reflux** unlike the **deep** disease usually happens because the **valves** or **vein** become weak and floppy as a person ages. This may cause the typical **varicose veins** which are easily seen ropey and large **veins** in the thigh or calf. In some people, **superficial reflux** may have no symptoms, may be noted as only very small **veins** (called “**reticular veins**”) or even smaller very thin reddish colored **spider veins** (called “**telangectasias**”).

**Perforating veins** connect the **deep** and **superficial veins**. With their one-way **valves**, they allow blood to flow from the **superficial system** into the **deep veins** and prevent back-flow. When the **perforating veins** are incompetent or leaky, this will also increase the pressure in the **superficial veins** and contribute to the **skin changes** of **chronic venous insufficiency**.

### **Chronic Vein Insufficiency Effects**

Regardless of the cause, **chronic venous insufficiency** and **chronic venous hypertension** may result in **leg swelling**, skin darkening or **hyperpigmentation**, skin thickening or **lipodermatosclerosis** (fat and skin scar development), and even sores or **ulcers**. Elegant studies have shown that there are several abnormal changes that happen in the **veins** which cause the **skin changes** seen. There is increased blood flow in the area of the **skin changes**. However, despite an increase in blood flow there is a decreased delivery of oxygen and life-giving food to the tissues. The leaking of red blood cells into the tissues through small holes in the vein walls helps to cause the skin staining or **hyperpigmentation** seen in the disease. Work is taking place to learn what is causing the wound or **ulcer** to form.

### **Commonly asked questions**

#### **Why do my legs swell?**

**Leg swelling** may happen for many reasons. When **venous disease** is the problem, it may be because of increased pressure in the **veins** from heart or lung disease or because the **veins** are not working properly. The **veins** may not be working well because the **valves** are worn out causing backward movement of blood into the leg (**reflux**). Other causes of **swelling** may include liver disease, kidney disease, medications, problems with water balance, or mechanical loss of the “**calf muscle pump**”. Your doctor can do laboratory testing and vascular testing to determine what conditions you may have.

#### **What if my swelling just happened and is only in one leg?**

**Swelling** that happens in only one leg may be more likely a problem with blockage or **obstruction** of the **vein**. If it just happened, you need to seek medical attention to make sure there is no acute **blood clot** forming in your leg **veins** (**deep vein thrombosis (DVT)**) or other important cause.

#### **What causes the veins to not work well?**

In many cases, **veins** may wear out because of a family trait (inherited) passed on to you. If you have a family history of **varicose veins**, this may not be avoidable. Trauma or injury to the **vein** is another cause for the **veins** to not work well. This is the case after a **blood clot** or **deep vein thrombosis**. After a **blood clot**, many people will suffer from changes related to the **post-thrombotic syndrome**. Your doctor can help to diagnose any of these problems.

## What can I do about my swelling and what can happen if I do nothing?

Once your doctor finds the reason for the **swelling** then treatment can be started. In many cases, elevating the foot of the bed to help get the blood out of your leg while sleeping or by using **compression stockings** while awake and upright may be very helpful. Of course, if there is a problem with your heart or other problems your physician will need to take care of these problems also. Keeping the skin moisturized may help with the dry skin changes. You will need to protect the skin of your leg from injury if you start to see thickening of the skin since then it becomes more likely to be damaged with very little bumps or cuts. Open wounds or **ulcer** can be seen usually at the ankle which needs medical attention to heal.

**Figure 1:** An artist's picture of the workings of a normal valve (first panel with two pictures) where the valve opens with calf movement and then closes to stop the reflux or backward movement of blood when standing still. The second panel show a valve which does not close properly and so allows blood to flow back into the leg when standing and immediately after your stop walking.

