ORIGINAL ARTICLE

Radiology and management of recurrent varicose veins: Risk factors analysis using artificial neural networks

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Abstract

Background: From the epidemiological point of view, certain factors involved in the appearance of varicose veins are preponderant such as multiple pregnancies, age, and also certain races. Physiologically, venous valve dysfunction can also be a factor. Here, radiologists intervene to determine venous insufficiency. Doppler ultrasound (US) and tomography are often the most used in this detection. Certain other factors contribute to their recidivism.

Aims: Some factors that occur in the recurrence of varicose veins are extrinsic such as age, sex, or genetic factor. On the other hand, certain factors are linked to an inadequate surgical procedure that can be partly explained by a poor radiological or methodological reading. The aim of this study is to prevent recurring complications that may occur the analysis of the factors of these is necessary.

Materials and Methods: In our study, 62 patients were operated in our general surgery department during the period from January 2016 to September 2017. The pre-operative clinical examination included, among others, the radiological examination using a Doppler US. Patients who have had a recurrence are classified from the identification of the possible causes. Since the causes are complex and vary from one person to another, this makes them very difficult to analyze by conventional methods. We proposed an intelligent system based on artificial neural networks.

Results: Once the system is established, this will identify the most important factor in the recurrence of varicose veins. By randomly changing the parameters at the input one by one and we record the effect that each produces on the recurrence rate at the output.

Conclusion: The proposed system with its very strong inters connectivity, and the support of all possible combinations with the weight of each factor makes it possible to extract the predominant cause. With its learning from the real values recorded, and the optimal function created between the two input-output spaces, it becomes very easy to identify the main cause that leads to recidivism.

Introduction

The risk factors for the appearance of varicose veins are not clearly defined. However, some are preponderant. Some are environmental; others age-related, multiple pregnancies in women, while others are typically physiological such as valvular dysfunction.[1] If the etiology of the disease is misunderstood, obesity, and work that requires standing for a long time, the genetic factor, may be risk factors.[2-6] Regardless of these factors, this is manifested by venous and valvular dilation.[2-4,7,8] Some epidemiological studies suggest that this may be the result of abnormalities in the enzymes involved in the functioning of homocysteine metabolism.[9]

The recurrence of varicose veins gives rise to significant expenses and a burden on public health, hence, the need for further studies in this area.[10] The main reported causes are related to the inadequacy of the surgical procedure on the great saphenous vein or also to the tributaries which enlarge by the

time.[11,12] Sometimes, it is new branching vessels.[13,14] Statistics report that recurrence accounts for nearly 24% in the groin have of neovascularization origin.[15,16] Unfortunately, there are no comparable systems for defining an operative strategy based on the anatomical classification of recurrences.[17-18]

The intervention of the radiologists consists in the determination of the main causes of the venous insufficiencies by demonstrating the valvular dysfunctions of zones affected by the varicose veins. The causes of varicose vein recurrence after surgery are multiple and very complex to define. There are no common causes for all patients. Some factors are recurring than others. In this study, an artificial neural network (ANN) analysis system is proposed. Since such a technique has the capacity to handle a large number of complex data, its application in this analysis is adequate.

Radiological used techniques

Radiological techniques that provide information related to these dysfunctions are generally Doppler ultrasound (US) and computed tomography (CT).[19] The role of the radiologist is not limited to reading the images. He must have the multidisciplinary knowledge regarding vein disorders. This will facilitate communication with the surgeon and the report prepared will accurate as possible. He must answer the question if these varicose veins are an isolated manifestation or if they are of origin a venous insufficiency related to hypertension. From there, he orients the patient. In this case, it must take into account several factors such as age, sex, geographical area, and environmental, and genetic factors including obesity and the number of pregnancies in women.[20] In the case of chronic venous insufficiency, Doppler can show venous reflux. This is achieved by compression of the calf in the case of proximal veins.[21] For this reason, the Doppler echo is the most used today in a pre-operative diagnosis.[22,23] Although pre-operative and in addition to Doppler US, duplex venous US examination for primary and secondary varicose veins offers good results.[24] Duplex US has the advantage of its large evaluation of hemodynamic information as well as its non-invasiveness and availability.[25-28]

However, to obtain an image of better quality, the best technique remains that of CT venography which allows having a general visualization[29,30] in addition to duplex sonography.[21] What is demonstrated is that the CT phlebography technique offers good image quality of the venous system and provides an overall anatomical overview. In three-dimensional, the accuracy of the information provided can be considered as a guide to the surgeon, especially as it gives a detailed insight into complex anatomical structures.[31]

Causes of varicose vein recurrence

Despite the development of radiological and surgical techniques, recurrence of varicose veins remains a problem. The causes of recidivism are multiple and vary from one person to another. Each person has a different anatomy. Several studies deal with possible causes. These causes may be related to poor understanding of vein anatomy or hemodynamics. However, it is very difficult to make an exact assessment of the reasons as long as the results vary widely from the preparatory evolution, treatment, classification, method used, and duration of follow-up.[32]

Causes include inappropriate preparation by radiologists. Furthermore, other factors can intervene like a neovascularization or an unsuitable and incomplete surgical gesture.[33] The progression of the disease, therefore, can be explained by the unsuitable surgery[34] and venous dynamics.[35]

Materials and Methods

In our study, 62 patients were operated in our General Surgery Department at the Setif University Hospital in Algeria during the period from January 2016 to September 2017. These patients underwent pre-operative clinical examinations. These examinations required a Doppler US to locate as precisely as possible the veins on which the surgery will be performed. Patients are classified by age, sex, obesity, and genetic factors.

Patients who have had a recurrence are classified from the identification of the possible causes of the reoccurrence of varicose veins in relation to the risk factors mentioned above, also, the time taken for varicose veins to recur after surgery. These probable causes to analyze are:
- Age
- Gender
- Obesity
- Genetic factor
- Inadequate assessment
- Double short saphenous
- Double long saphenous
- Neovascularization
- Incompetent surgery
- Period of recidivism.

The purpose of this study is to identify the probable reason for this recidivism to avoid it later. If certain factors are impossible to act on, such as age, sex, and genetic factor, for example, other factors are to be studied closely.

If the responsibility of the surgeon is engaged, this can be caused by a misinterpretation radiological. From there, the radiologist is as responsible as the surgeon. With the advent of new radiological techniques, the problem can be partially alleviated.

ANN analysis

Like the biological neural network, ANNs are designed to solve complex systems. An ANN is composed of an input layer, a hidden layer, and an output layer. It is about matching the inputs and the output. The network is strongly connected encompassing all the possibilities encountered. The main phase in a neural network is learning. At this level, it is to teach the network the correspondence between the two input-output spaces. A transfer function is established. If an input variable is modified, it also

Table 1: Varicose veins operated at the level of our service between January 1, 2016 and September 30, 2017

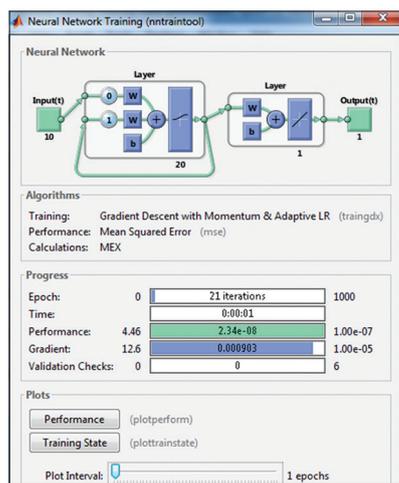| Age	Gender	Obesity	Genetic factor	Inadequate assessment	Double short saphenous	Double long saphenous	Neovascularization	Incompetent surgery	Period of recidivism	Rate
1	1	1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2	2	2
3		3	3	3	3	3	3	3	3	3

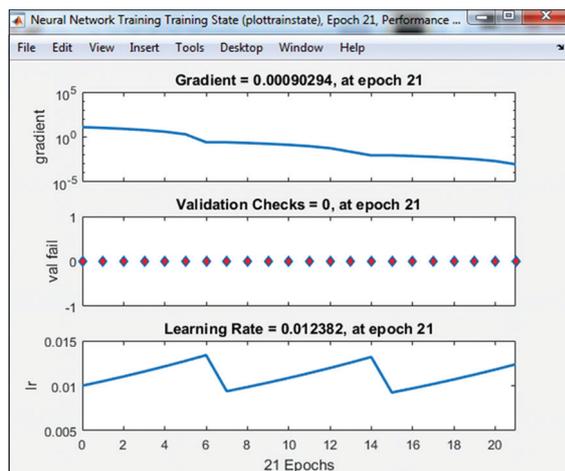**Figure 1:** Block diagram of the system

Figure 2: Optimum at 21 epocs

corresponds to a variation of the output variable. The advantage is that it is not necessary to change the whole network, but the adjustment of the function is done by the variation of the weights which are nothing but mathematical coefficients in the function of transfer. ANNs have the dynamics to analyze in reading the experimental data of the real environment to solve the complex situations in the biophysical processes.[36] This makes ANNs find their applications in different fields including medical sciences.[37]

In our case, a system is constructed with the input variables are the probable causes of varicose recurrence and the output variable is the recurrence rate of it [Figure 1].

Each number of cases recorded whose recidivism attributed to one of the cited causes is encoded in three intervals.[1-3] Each interval represents a degree of relevance in its category. For example, for age, this factor is subdivided into three intervals 1: For people aged 0–25 years, 2: For people between the ages of 25 and 50 years, and 3: For the elderly over 50 years old. The same reasoning of encoding is applied to the other variables in terms of number. For obesity, it is expressed in body mass index … etc., except for the sex where he is counted (1 for the masculine and 2 for the feminine) [Table 1].

Learning the neural network

By setting the values at the input of the system that are related to the risk factors for the recurrence of varicose veins as well as the recurrence rate expressed by its interval code according to the number recorded at the output, the system establishes a transfer function between the two spaces. When introducing another combination (inputs-output), the system adjusts the function by acting on the weights of the connections, which are mathematical coefficients. When all combinations have been introduced, the system adjusts the function to its optimum with the minimum of errors [Figure 2].

Results

The data are read directly from an Excel file with corresponding inputs and outputs. The reading for learning the network is done line-by-line intermittently. When the function is created and adjusted, the instruction is given to reread the remaining lines for the function test. It is found that at 21 iterations, the function reaches its optimum. The error is $2.34.10^{-8}$.

Once the system is established, this will identify the most important factor in the recurrence of varicose veins. By randomly changing the parameters at the input one-by-one, and we record the effect that each produces on the recurrence rate at the output.

Conclusion

The causes of onset and especially recurrence of varicose veins are multiple and complex. These causes vary from one person to another. If some factors are extrinsic, other factors may be subject to adjustment. When it comes to a poorly performed surgical procedure, this can be caused by a poor radiological reading, either in the technique or in the methodology used. To identify this, and since the environment is very complex, the proposed ANN system allows to locate the fault. The proposed system with

its very strong inters connectivity, and the support of all possible combinations with the weight of each factor makes it possible to extract the predominant cause. With its learning from the real values recorded, and the optimal function created between the two input-output spaces, it becomes very easy to identify the main cause that leads to recidivism. This system can be a tool to help the surgeon and the radiologist to improve the intervention and thus reduce the recurrence of varicose veins in the lower limbs.

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