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Hyperlipidemia and Aneurysm: Artificial Neural Networks Analysis

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ORIGINAL RESEARCH ARTICLE

Abstract

Abdominal aortic aneurysm (AAA) is a multifactorial vascular disease with high mortality which is related to advanced age. It is a silent disease and is detected accidentally when a patient is diagnosed with another disease. Doppler's ultrasound is the first analytical tool followed by CT for more details. As the factors that promote this disease are complex and varied, this study proposes their analysis using artificial intelligence techniques.On a sample of 100 patients diagnosed in our radiology department at the University Hospital of Setif in Algeria with other private sector clinics during the period 2019-2020, different factors are taken depending on the diameter of the abdominal aorta. The proposed data analysis addresses the hyperlipidemia-aneurysm relationship. An artificial neural network analysis system is proposed. Of the values of the variables of the 100 people involved in the study, it used 50 cases for learning the network and the remaining 50 for testing the function created. The results clearly show that the test values merge perfectly with the learning values. View the complexity of the process and the diversification of factors and human physiology. This proposed approach makes it possible to predict the diameter of the abdominal aorta from the hyperlipidemia values of patients before confirmation by radiological diagnosis. They can use this as a diagnostic aid.

Key words: Hyperlipidemia, Aneurysm, Artificial neural networks

I. INTRODUCTION

The term "aneurysm" denotes a "localized increase in arterial diameter with a permanent loss of parallelism of the artery wall" [1]. An abdominal aorta is aneurysm when its diameter is greater than 30 mm or 1.5 times the normal diameter or upstream diameter and after, according to the French Society of Vascular Medicine and the European Society of Cardiology [2];[1]. The aneurysm is a multifactorial disease. It especially concerns the elderly and is more common in men than in women. Abdominal aortic aneurysm (AAA) is a condition that increases in frequency with age; rupture dominates its main risk with > 80% mortality [4];[5]. AAAs is usually located under the renal arteries and end before the bifurcation of the aorta. The main risk factors for developing AAAs are smoking, hypertension, advanced age, male gender, atherosclerosis, dyslipidemia or hyperlipidemia, positive family history, and hereditary predisposition. The risk factors for developing AAA are not strictly the same as the risk factors for rupture.

Given the complexity of the factors and their imprecision, this study offers an analysis of data relating to diagnosed patients. Conventional statistical analysis is lacking in precision, and analysis using artificial intelligence techniques is proposed. The principles of artificial neural networks are applied. As these networks can process complex and varied data, it allows for a clearer and more precise vision. Their application in this area is then adequate. Given the complexity of the phenomenon, the artificial neural network system proposed makes it possible to deal with this complexity. This gives the possibility of predicting the diameter of the abdominal aorta.

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II. METHODS

A. RISK FACTOR

Cholesterol, triglycerides, and high-density lipoproteins can directly result from the hyperlipidemia abnormality. By its effect, cardiovascular diseases can appear. Therefore this anomaly is considered a risk factor for abdominal aortic aneurysm (AAA). Studies have shown a direct link between the levels of triglycerides, the aneurysm, and those with the manifested aneurysm. It considerably elevated this rate compared to the rest of the population [6]. Also, cholesterol levels were directly related to the incidence of AAA [7].

Different studies suggest the link between the aneurysm and the damage to the vascular system by the crystals of cholesterol and which lipids can cause inflammatory factors and the response to these causes vascular endothelial damage and connects with the AAA [8];[9]. Several factors are involved in the development of AAA. These factors are complex and uncertain. This study deals with the hyperlipidemia-aneurysm relationship. Since it is very difficult, if not impossible, to analyze the phenomenon mathematically given its complexity, the use of an artificial intelligence technique, in particular artificial neural networks, is proposed.

B. ROLE OF IMAGERY

As the first diagnostic tool for aneurysms, they used Doppler ultrasound as a preparatory vascular diagnostic technique [10];[11]. In addition, as this technique is invasive, it allows the detection of vascular disorders, and therefore it is necessary for the orientation of the surgical act [12-14].

Usually, this diagnosis is confirmed by tomography CT for more details. CT computed tomography offers a better reading with more details, particularly of anatomical structures [15-17].

The study is carried out on 100 patients diagnosed in the radiology department of the Setif hospital in Algeria and in nearby private service clinics over a period from 2019 to 2020. It carried preliminary analyzes out to take different factors, between others hyperlipidemia.

On it, match the diameter of the abdominal aorta with it. These data are far from precise in explaining their effect on the aneurysm. Their analysis by artificial neural networks is applied.

C. ARTIFICIAL NEURAL NETWORKS

Through this dynamic of reading experimental data and solving complex situations, these networks nowadays find their applications in various fields, notably medical.

Artificial can store information for later retrieval [18]. The main characteristic of these networks is learning [19]. Studies show the ability of these networks to represent variables and data structures. [20];[21].

An artificial neural network consists mainly of an input space of a hidden layer and an output space. During learning, we created an equation between the two input-output spaces. We adjusted this function to its minimum error. The system built is shown in Figure 1.

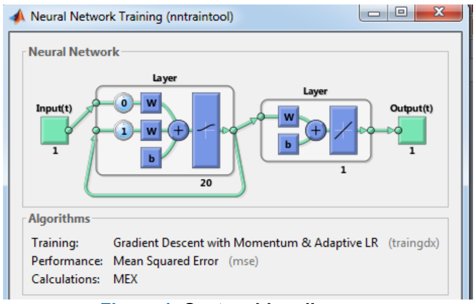

Figure 1. System bloc diagram

We used Matlab 2016a for data processing.

III. RESULTS AND DISCUSSION

For each patient diagnosed, when the parameters taken concerning hyperlipidemia and matched with the diameter of the aorta measured, a transfer function is created.

Measurements of the diameters of the aorta vary over a wide range. The variations of measured values are measured with accuracies up to mm. (Figure 2).

Figure 2. Partially thrombosed fusiform aneurysm of the infrarenal abdominal aorta measuring 39*44 mm.

If the studies report that the surgical act occurs when the maximum diameter exceeds 55 mm [22-24], nowadays recent studies try to identify the predictors of this development of the aneurysm to establish a personalized risk assessment [25]. Adding to the diameter of the aorta, measurements of its length and volume provide information about its development. However, there are no studies to date regarding the volumetric prediction of the evolution of the aneurysm [26-28].

It is noted that it is very difficult to determine with precision the effect of hyperlipidemia on these minimal variations in diameters. Faced with this complexity, the application of a neural analysis is adequate.

The values of the measured diameters are matched with the presence or absence of hyperlipidemia in each patient.

During learning, the weights of each input-output are modified to optimize the transfer function. By this process, it is unnecessary to change the network for each variable but to just adjust the weights, which are only mathematical coefficients.

The function is thus adapted to the new situation. With several cases considered in learning, the function is therefore readjusted to its minimum error.

In our case, 1000 loop iterations are planned in order to achieve a minimum error. It was found that at 100 iterations the optimum result is reached with an error of 1.10^{-7} (Figure 3).

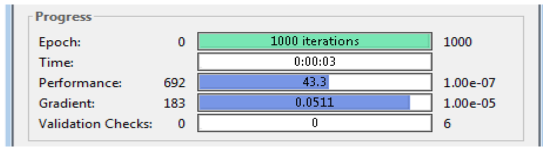

Figure 3. Schematic of the error correction system when learning the "Hyperlipidemia" network

It then becomes possible to calculate the diameter of the abdominal aorta from the function shown in Figure 4. This function is created during the network learning phase. That is to say with 50% of the diagnosed cases. For its validation, the remaining 50% are used for the test of the function which shows that they merge perfectly.

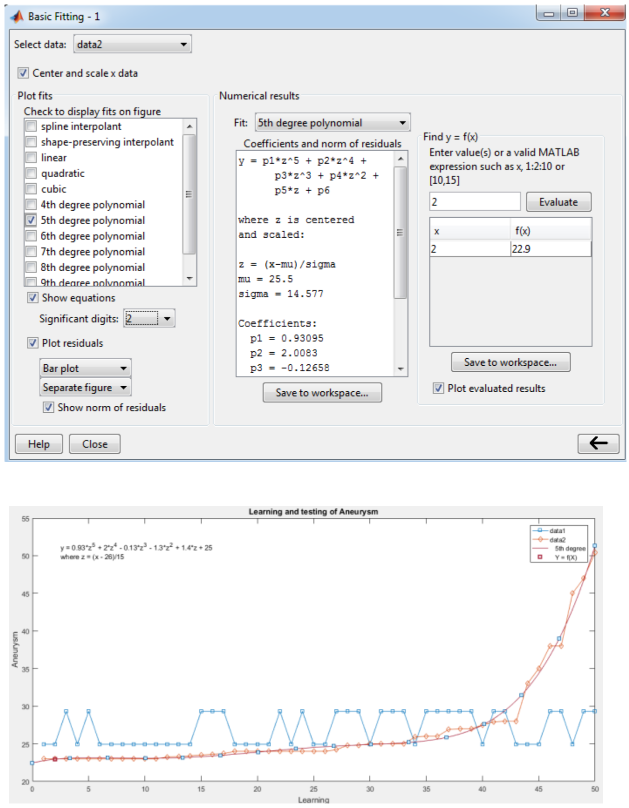

Figure 4. Variation of the aneurysm as a function of the variable "Hyperlipidemia"

Figure 4 illustrates the variation in the diameter of the abdominal aorta depending on the absence or presence of hyperlipidemia. What noticed is that after optimization of the function, the test values merge with the learning values.

The completed system allows you to assign a value to the presence or absence of hyperlipidemia to automatically read the probable value of the predicted aortic diameter.

IV. CONCLUSION

The factors that promote aneurysms are many and complex. Some are known, but their real impact remains to be defined. Others are totally ignored. Faced with this situation, this study presents an intelligent analysis of the effect of hypolipidemia on the diameter of the abdominal aorta. In a study sample presented to our radiology department, we performed tests for the presence or absence of hypolipidemia.

Using the Doppler ultrasound technique and confirmed by CT tomography, the diameter of the aorta is measured. As the system is complex, an artificial neural network is proposed in this data processing. A mapping between the two input-output spaces is done. A transfer function is created between the inputs-outputs and is optimized to its minimum error. After learning the network, it becomes possible to introduce randomly a value at the input to read the value at the output and therefore predict the aneurysm before radiological diagnosis. We can use this as a diagnostic aid.

Conflict of interest. None to declare.

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