Artificial neural networks analysis of the risk factors for aneurysm in the population of the Setif region in Algeria

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Abstract: **Background**. By definition, when the abdominal aorta undergoes dilation, this is called an aneurysm. However, this definition depends on the threshold diameter of the aorta reached after dilation. According to angiographic studies, aneurysm is considered when the diameter of the aorta exceeds 30 mm. According to the International Society for Cardiovascular Surgery/Society for Vascular Surgery Ad Hoc Committee, we speak of an aneurysm when the diameter of the infrarenal aorta exceeds 1.5 times the normal diameter. It then becomes necessary to define the normal value of this diameter, which varies from 16 to 23 mm depending on the population concerned. Ultrasound is often used in screening for abdominal aortic aneurysms (AAA) for its simplicity and low cost. This study evaluates the prevalence of abdominal aortic aneurysms in the population at risk in the region of Setif in Algeria. **Method and materials**. The study concerns a population of The study concerns a population of 902 diagnosed cases, 854 cases are over 50 years old who consented to AAA screening who consented to AAA screening. For each patient, different parameters are taken. Physical and ultrasound examinations are performed. The parameters sex, history of diabetes, dyslipidemia, blood pressure, body mass index, smoking and atherosclerosis are listed. In order to establish an average diameter of the aorta in this population at risk, an intelligent analysis relating these factors to the diameter of the abdominal aorta is applied. **Conclusion**. As the system is very complex to analyze using classical mathematical techniques, the principles of artificial neural networks come in handy. The rule base that maps the input variables to the diameter of the aorta is created from the database of the performed analyzes. This makes it possible to predict the diameter of the abdominal aorta from the risk factors. Therefore, prevention of abdominal aortic aneurysm will be possible in the population of this geographic area.

*Key words***:** Aneurysm, Abdominal aorta, Normal diameter, Aneurysm, Intelligent system, Fuzzy logic

Received: June 8, 2021. Revised: April 10, 2022. Accepted: May 8, 2022. Published: July 1, 2022.

1 Introduction

An increase in the diameter of the arterial aorta with a loss of parallelism of its wall defines the abdominal aneurysm [1]. There are several definitions that are defined as the diameter reached by the aorta. We speak of an aneurysm in certain definitions when the diameter is greater than 30 mm, either according to the French Society of Vascular Medicine and the Cardiology Society of the European Union [2]. While the International Society for Cardiovascular Surgery/Society for Vascular Surgery Ad hoc Committee proposes that an AAA be defined when the maximum diameter of the infrarenal aorta is at least 1.5 times greater than the infrarenal aortic diameter normal kidney [3]. As for the definition which considers the aneurysm when the diameter of the aorta exceeds 30 mm, it fixes this threshold as being the limit of the non-reversibility of the dilation [4-7]. This definition does not differentiate between the sexes. Because its value is lower in women than in men and in patients with arteriomegaly [4]. Several factors cause the aneurysm factors such as age where an increase is observed in the risk of rupture and even death by up to 80% [8-9]. Generally, the risk factors are mainly smoking, hypertension, advanced age, male sex,

atherosclerosis, dyslipidemia or body mass index, and even race.

The aneurysm is considered a silent disease without symptoms [10]. It is necessary to establish a screening and monitoring program for people at risk [11]. Faced with the need to define the risk threshold according to the definition which sets this threshold at 1.5 times the value of the normal diameter, it is necessary to set the normal diameter in a population at risk. To determine this value, it is necessary to consider all the factors involved. The system turns out to be very complex to analyze using classical mathematical methods. The proposal of an intelligent system with artificial neural networks is used to compensate for the uncertainties inherent.

2. Material and methods

This study samples the diameter of the abdominal aorta from 902 diagnosed patients at the level of the radiology department of the University Hospital of Setif in Algeria and in the surrounding private sector clinics.

This study was spread over a period from 2018 to 2021. Clinical and physiological parameters are taken from each patient such as sex, age, atherosclerosis, body mass index, hypertension, and dyslipidemia. As ultrasound remains the most available and least invasive means, as well as radiological technique in the detection of vascular dysfunction [12-15], this technique was used in our determination of the diameter of the abdominal aorta. (Figure 1). Among the 902 diagnosed cases, 854 cases are over 50 years old. They are therefore people at risk. For this category, the average diameter of the aorta is calculated (20.47 mm). As the value of this diameter is a function of several parameters, The values of the diameter of the aorta is considered as output variable. The factors that determine it are considered as input variables.

ANN system

The general principle of artificial neural networks (ANN) is an imitation of the natural neural network. The network comprises two spaces (inputs-outputs).

Artificial neural networks have the dynamics and ability to read experimental data from the real environment and can therefore solve complex systems of biophysical processes. Neural networks are systems learning to perform mapping functions between two spaces: input space and output space.

The matching between the two spaces from the actual measured values allows creation of a transfer function between the two spaces. Each time we fix the values for the input variables and their corresponding output variable (diameter of the aorta), the function created undergoes readjustments. This readjustment takes place through the modification of the mathematical coefficients [16-18].

This is the learning phase of the network. The network created remains the same without changing it in each case, but these readjustments of the function carry the adaptation out

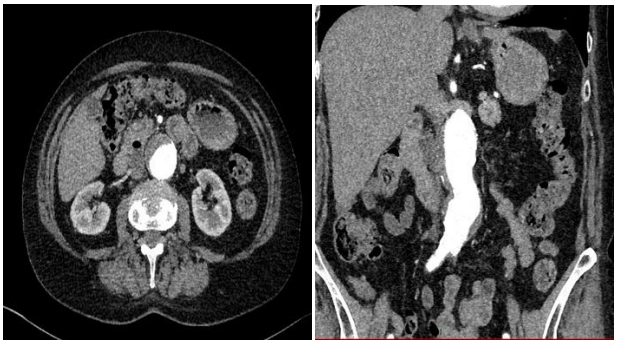

Figure 1. Partially thrombosed fusiform aneurysms of the infrarenal abdominal aorta. The first nascent 50 mm below the ostium of the left renal artery, extending 5.5 cm in height with a maximum diameter of 40 mm.- The second S1, extending to the bifurcation extended aorto-iliac, about 40 mm

ANN modeling

In order to predict the average diameter of the population of the region of Sétif in Algeria, the value of the diameter recorded for each patient is correlated with the clinical parameters measured. (age, sex, BMI, blood pressure, hyperlipidemia, and atherosclerosis) The built system allows a correspondence function between the two spaces. (Figure 2).

The variables sex, atherosclerosis, hypertension, and dyslipidemia are coded (1 and 2) to express the presence or absence. The real values express age and body.

MATLAB 2016a is used as the compiler.

The mathematical expression that connects them is of the form:

$$f(ad) = a,g,b,ap,h,at$$

Where:

ad: diameter of the aorta
a: Age
g: Sex
b: BMI
ap: blood pressure
h: Hypolipidemia
at: atherosclerosis

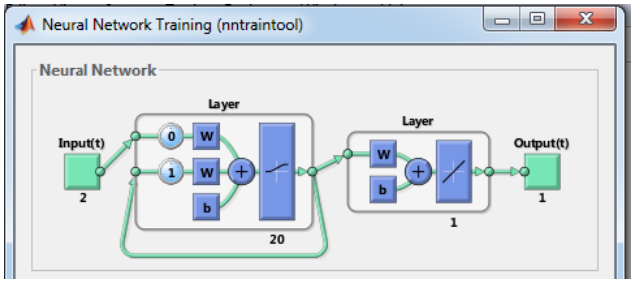

Figure 2. Input-output system with hidden layer

Of the 854 cases whose age is greater than 50 years, half of 427 cases, their clinical parameter variables are introduced at the entrance to the system and the corresponding aortic diameter. During this so-called network learning phase, it created the transfer function. I fit this function with the method of the fewest squares. The gradient is 0.313. The number of adjustment loops is 1000 (Figure 3).

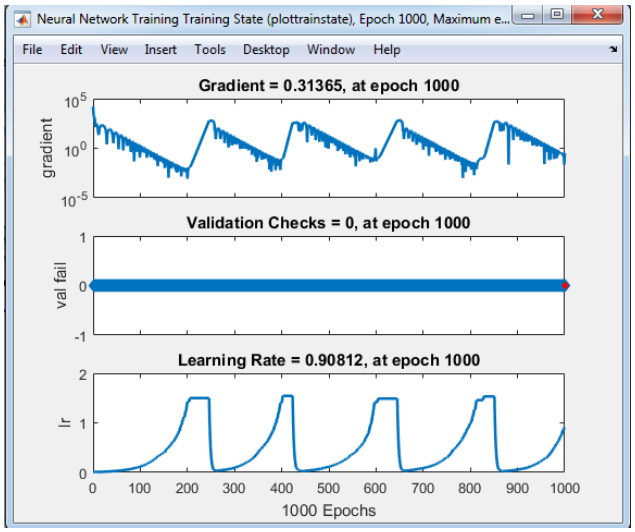

Figure 3 Adjusting the function during the learning phase

When the function is created and adjusted to its minimum error, we inject the other half of the remaining cases for the test phase. Note that the test values coincide perfectly with the learning values (Figure 4).

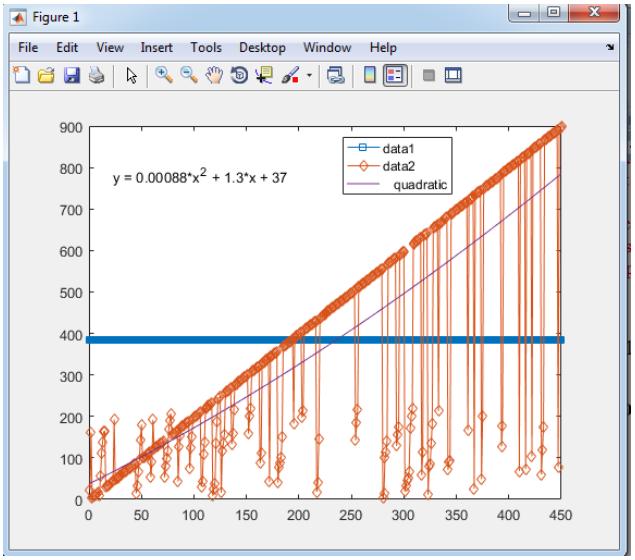

Figure 4. Confusion of test values with learning Values

3. Result

The function *f(x)* created and adjusted with so-called weight coefficients is presented in Figure 5. This function takes care of all the variables and makes it possible to introduce random values at the input to read at the output in terms of the diameter of the corresponding aorta. Example (Figure 5): Randomly set values (1:55:2) refer to a male subject, 55 years old and with atherosclerosis. The probability of having an aneurysm is represented by a predicted aortic diameter of 38.5 mm.

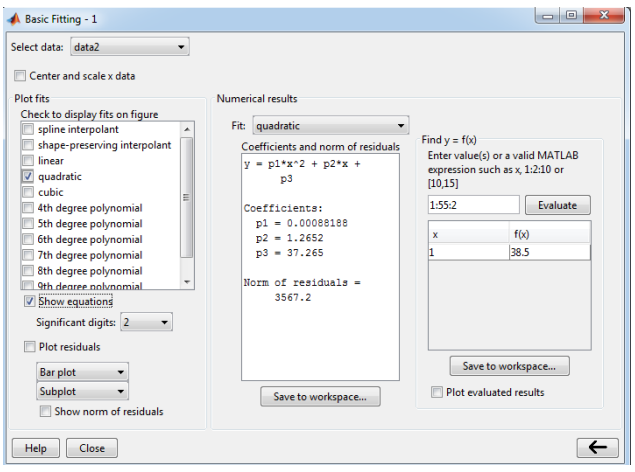

Figure 3 Quadratic function (inputs-output)

4. Conclusion

The diameter of the aneurysmatic abdominal aorta is often determined by its rate of dilation relative to its average value (1.5 the average value). This value is specific to each population in a geographic area. The study carried out on the population of the region of Setif in Algeria made it possible to match the factors favoring aneurysm in this population. The complexity of the system and the interference of the effects of the factors led us to propose a system with artificial neural networks in the analysis of these data. The proposed algorithm makes it possible to create a transfer function between the two input spaces (risk factors) and the output space (the diameter of the aorta). We adjust this function to its minimum error by learning the network for half of the cases and tested by the variables of the other half. This makes it possible to predict the diameter of the abdominal aorta from the risk factors. Therefore, prevention of abdominal aortic aneurysm will be possible in the population of this geographic area.

Financial support and sponsorship:

Nil.

Conflicts of interest

There are no conflicts of interest.

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