Effect of Hyperlipidemia on Aneurysm: Fuzzy inference analysis

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Abstract: - **Introduction:** The abdominal aortic aneurysm is a silent disease. This disease is often detected by accident when diagnosing another disease. There are many factors that promote this disease. These factors are mainly related to age. Doppler ultrasound can detect this disease. But often and for more details, we resort to the scanner. Since the factors that characterize this disease are multiple and complex, this study proposes to analyze them using artificial intelligence techniques. **Method**: During a period of two years between 2019 and 2020, around 100 patients are diagnosed at the Sétif hospital in Algeria as well as in other private clinics in the city. At each diagnosis, the diameter of the aorta is measured and related to hyperlipidemia. A system of analysis using the principles of fuzzy inference is proposed in the data processing. **Result**: With the development of this application, it becomes possible to introduce the variables of hyperlipidemia randomly at the input of the system to automatically read the diameter of the abdominal aorta possibly planned. **Conclusion**: By considering hyperlipidemia as a fuzzy variable, because it is a function of other complex physiological parameters, this fuzzy analysis makes it possible to compensate for these uncertainties. The diameter of the abdominal aorta predicted for the hyperlipidemia will be as precise as possible. This tool can be considered as a preventive aid for the aneurysm.

*Key words***:** Aneurysm, hyperlipidemia, intelligent modeling, fuzzy logic

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1 Introduction

A localized deformity of the arterial diameter often characterized by loss of parallelism is referred to as an "aneurysm"[1]. We speak of aneurysm as a disease when the arterial diameter exceeds 30 mm or 1.5 times the normal value of the diameter[2];[3]. This patient is mainly related to age. It concerns men much more than women. With age, several complex physiological factors are involved in the onset of this disease. At its critical threshold, the aneurysm can lead to rupture of the abdominal aorta and even death in proportions of up to a threshold above 80% [4];[5]. Abdominal aortic aneurysms are usually located below the renal arteries and end before the aortic bifurcation.

There are many risk factors. All of these factors are related to age, including smoking, high blood pressure, atherosclerosis, hyperlipidemia as well as the genetic factor. It should be noted that the risk factors are not the same as the disruptive factors.

Taking into account that these factors are complex and imprecise, this study is limited just to the analysis of hyperlipidemia and which itself is dependent on other factors. Also, we see that the classical mathematical tools of analysis are very difficult if not impossible. This study proposes a tool based on artificial intelligence techniques. The principles of fuzzy logic are applied to this data processing. Since fuzzy inference treats the variables as uncertain variables, these uncertainties are compensated using this mode of analysis and the result will be as precise as possible.

2. Risk factors

This study is limited to the hyperlipidemia factor. This factor can be the cause of other abnormalities such as cholesterol, high density lipoproteins or triglycerides. This can lead to cardiovascular disease. From there, appears the importance of analyzing hyperlipidemia, because, alongside these abnormalities, it is a cause of the appearance of abdominal aneurysm (AAA).

Findings were made in people with high triglyceride levels where the aneurysm is reported compared to the rest of the population [6]. Also, the direct link between cholesterol levels and the aneurysm is found [7]. Cholesterol can cause crystal damage to the vascular system and lipids are sometimes the cause of inflammatory factors and endothelial damage associated with the abdominal aneurysm [8-12]. Add to that, lipoproteins are directly linked to the abdominal aneurysm. This is reported in other studies [13];[14]. The lipoproteins can be taken as an indicator of the aneurysm [15].

In summary, different factors are linked. These factors are very complex to analyze by classical mathematical techniques. The hyperlipidemia-aneurysm relationship is analyzed in this study. What characterizes these patients is that they are of advanced age and mainly male.

Given its complexity and uncertainty, an intelligent analysis is proposed. The principles of fuzzy logic are applied.

3. Role of imagery

Doppler ultrasound is considered the first preparatory vascular diagnostic technique [16];[17]. This technique has the advantage of being invasive and allows the detection of certain vascular anomalies. From there, it is necessary to orient the patient towards the surgical act [18-20].

For the purpose of confirmation, this diagnostic step can be followed by a CT scan which reveals more details. For more affinity, CT computed tomography presents more detail especially when it comes to anatomical structures [21-[23].

4. Materials and methods

A sample of 100 patients is diagnosed in the radiology department of the Setif hospital in Algeria and in nearby private service clinics over a period from 2019 to 2020. Patients likely to have an aneurysm are subjected to the preliminary analyzes the rate of various factors. Among these factors is hyperlipidemia. Doppler ultrasound imaging is used in these patients. Confirmation is made by CT tomography. Abdominal aortic diameter measurements are linked with hyperlipidemia. In addition to this factor, the age and gender of the patients are taken into account.

To analyze these factors, a fuzzy inference system is proposed. The system is constructed with three input variables (Age, Gender, Hyperlipidemia) and the diameter of the abdominal aorta as an output variable (Figure 1). All of these variables are considered uncertain and therefore fuzzy variables. Each variable is fuzzyfied. It is an operation, the numeric variables are converted into linguistic variables in human language. This helps to compensate for these uncertainties. A rule base is built that supports all possible combinations between input and output variables. The general form of the rule base is: [IF… THEN] [24].

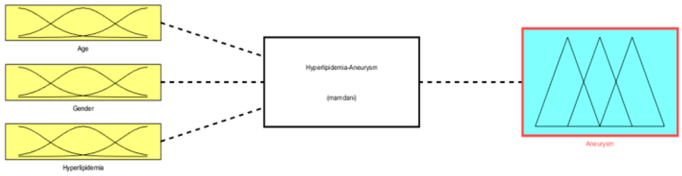

Figure 1: Block diagram of the system

4.1. Fuzzyfication of variables

4.1.1. Input variables:

- The input variable 'Age' is fuzzyfied into three triangular shaped membership functions:
  Young: [0 - 30 years old]; Adult: [25 - 60 years old]; Old: [55 - 100 years].
  We see the creation of an overlap interval between two neighboring functions to compensate for the imprecision associated with the allocation of ages (Figure 2].

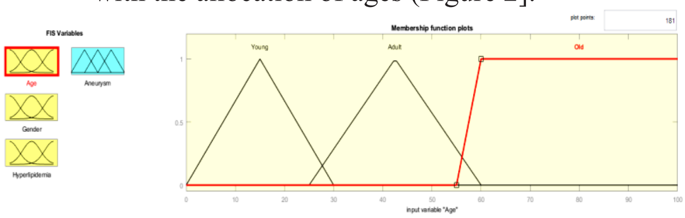

Figure 2. Fuzzyfication of the variable 'Age'

- The input variable 'Gender' is not fuzzyfied. Numerical values are assigned to each genre.
  Male: [1] ; Female: [2] (Figure 3].

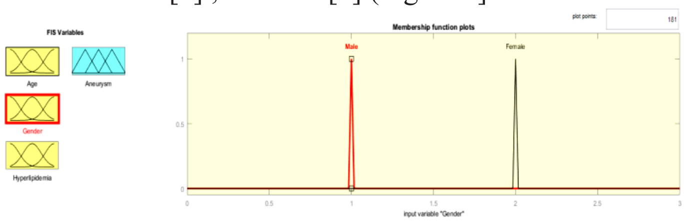

Figure 3. Representation of the variable 'Gender'

- The input variable 'Hyperlipidemia'is fuzzyfied into three triangular shaped membership functions. Hyperlipidemia is assigned numeric ranges based on their severity.
  Low: [0 - 2] ; Medium: [1 - 3] ; High: [2 - 4].
  We note the creation of an overlap interval between two neighboring functions to compensate for the imprecision related to the assignment of the degrees of severity (Figure 4].

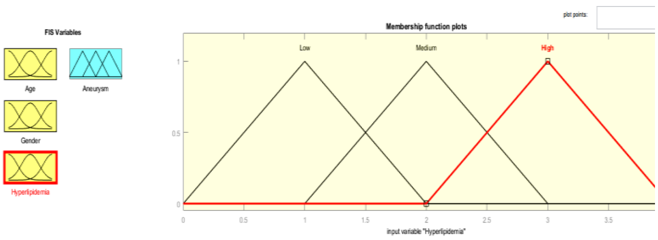

Figure 4. Fuzzyfication of the variable 'Hyperlipidemia'

4.1.2. Output variable

- The output variable represents the diameter of the abdominal aorta. This variable is fuzzyfied into three triangular shaped membership functions:
  Normal: [15 - 25mm] ; Risky: [20 - 40 mm]; Serious : [35 - 60 mm] (Figure 5].

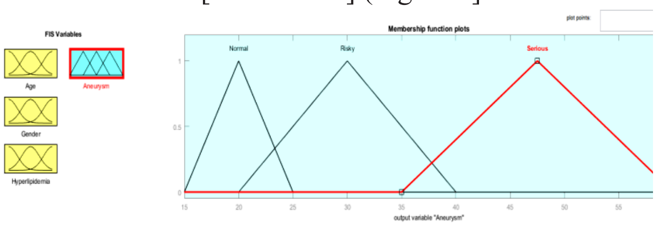

Figure 5. Fuzzyfication of the variable 'Diameter'

4.2. Basis of the rules

This is to establish the correspondence between the input variables and the output variable. This link is made from the actual values measured during the analysis carried out and the aorta measurements obtained by imaging. The rule base must contain all possible combinations.
The mathematical formulation can be written in the form:

d = f (a, g, h)
Where: d (diameter of the aorta)
a: (age)
h: (hyperlpidemia)

The general form of a rule:

IF d is x1 AND a is x2 AND h is x3 THAN d is Y

5. Conclusion

Studies prove the direct link between aneurysm and various factors that promote it. What characterizes these factors is complexity, uncertainty and imprecision. The weight of the effect on certain factors is known. The precise effect of other factors is poorly understood. While in other factors this effect is totally ignored. The fuzzy analysis proposed in this study supports this incompleteness and imprecision. By considering these variables as fuzzy variables, this uncertainty is compensated for. Once the basis of the rules is established from the actual measured values and all possible combinations are introduced, the output variable expressing the diameter of the aorta will be possible with maximum precision. The result expressing the diameter of the aorta is calculated by aggregating all the rules introduced. When the system is established, the result is that the system provides the ability to introduce random variables at the input to automatically read the likely value of the diameter of the aorta at the output (Figure 6).
In the absence of a systematic screening program for the aneurysm, this tool is intended to provide preventive support for this disease.

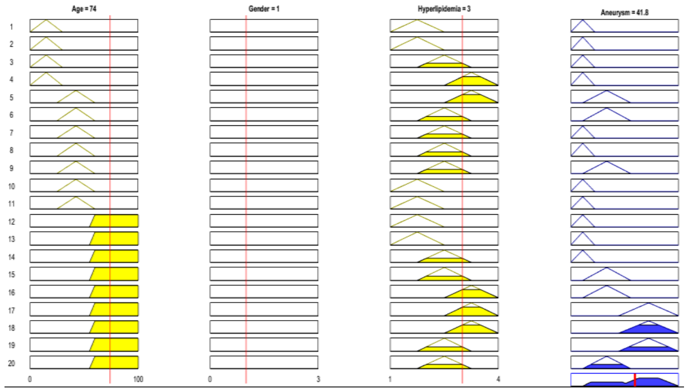

Figure 6. Example of application

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Conflicts of interest

There are no conflicts of interest.

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