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CHOLESTEROL IN HUMAN BODY: IMPORTANCE AND DOSAGE

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ABSTRACT

For a healthy life, specialists recommend us to take care of what food we eat and to what extent we do it and how we approach a satisfying lifestyle. Cholesterol is not a bad thing, but often, in large quantities it becomes dangerous for human body. The medical world is faced with frequent changes in the concept of "normal values" of cholesterol, but also with a continuously developing pharmaceutical industry in this field, and the tendency is in this sense, towards an individualized treatment. This aspect in presented in our paper, which aims to describe the role of cholesterol in the functioning of human body; preventing the occurrence of heart diseases due increasing the level of cholesterol in the body and creating a healthy lifestyle that can reduce cholesterol levels. The paper presents some case studies on laboratory investigations of values cholesterol that includes determinations, studying and the research of medical equipment (Cobas Integra 400 Plus analyser), but also the results obtained during practice in the medical analysis laboratory.

KEYWORDS: cholesterol, low-density lipoproteins (LDL), high-density lipoproteins (HDL), Cobas Integra 400 Plus

1. Introduction

Cholesterol is a lipid with the chemical formula $C_{27}H_{46}O$. Is based on sterol with molar mass 386.65 g/mol, melting point 146-147 °C and boiling point 200 °C (Figure 1). Cholesterol is identified in the cell membrane and in the tissues, it is transported in blood and concentrates at the level of the spinal cord of the liver, the brain, and at the level of the plate of atheroma forms cholesterol stones leading to atherosclerosis. It is not absorbed through food having an important role in the body. It is the precursor to various processes produced in body [1-3]. In excess, cholesterol (cholesterolemia) leads to vascular diseases: cerebrovascular, cardiac, ocular, very life-threatening accidents.

Two fractions of cholesterol are known: LDL cholesterol represented by low-density lipoproteins, in popular terms "bad" cholesterol and HDL cholesterol, or the "good" cholesterol represented by high-density lipoproteins.

Cholesterol is the factor responsible for several biochemical processes produced in our body when its values are within normal limits. When the values cholesterol is modified beyond normal limits, problems appear, being perceived as "the enemy of health". Of the two forms of HDL cholesterol and LDL cholesterol, we note the fact that LDL (bad cholesterol) deposits on the walls of the arteries and can cause heart diseases in case which doctors will recommend a more complex analysis called a lipidogram [4].

Researchers from the Heart Research Institute in Newtown Australia found that there is a close connection between high cholesterol and the risk of developing a mental illnesses dementia. Statistical data from over 1 million patients worldwide were analysed, with ages below 65 years, in 17 international studies and confirmed a worsening of the incidence cognitive decline for high cholesterol. Mild cognitive impairment can evolve into severe forms in correlation with high cholesterol. The normal cholesterol level is 5.17 mmol/L, and every increase of one mmol/L causes dementia to worsen by 8%. 75% of cholesterol is manufactured in the liver, in dietary fats and 25% comes directly from food. According to statistics, as patients grow and age, it is expected that in 30 years of from now on the numbers will double, reaching an average of 850 thousand sufferers of dementia [5].

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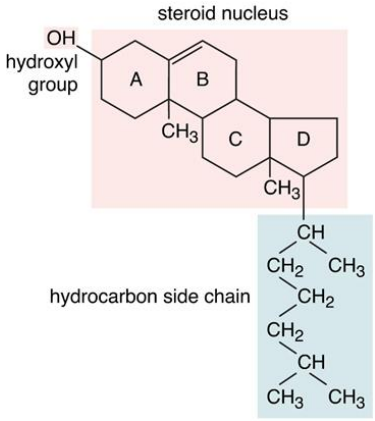

Fig. 1. *Chemical structure of cholesterol Source: https://www.britannica.com/science/cholesterol*

Teenagers and young people up to the age of 30 with a level increased cholesterol, risks the appearance of heart diseases: heart attack; of vascular accidents cerebral or other cardiovascular diseases in middle age. People who have managed to lower cholesterol levels to normal values, before reaching 40 years. Increased cholesterol inherited from families with pathologies such as heart attacks or accidents vascular, is more dangerous than cholesterol caused by unbalanced diet, because evolves rapidly. The risk of inheriting cholesterol is higher when both parents have it suffer from conditions related to blood lipids ≈ 75% [6].

The role of cholesterol in the body are maintaining cellular integrity; regulation of blood viscosity; bile synthesis; in the metabolism of hyposoluble vitamins A, K, E and vitamin D; decisive is also the precursor role of steroid hormone synthesis reactions, (cortisol and aldosterone in the adrenal glands) and sex hormones (progesterone, testosterone, estrogen); intervenes at the level of nerve synapses and in the immune system, including against cancer [7-9].

Cholesterol consumed in excess (fats) leads to adverse effects and most importantly among these is the atherogenic effect causing the vascular abnormality also called atherosclerosis. This is caused by the thickening of the lumen of the arteries by the deposition of lipids on the wall's vessels, leading to increased cardiovascular risk.

Because of this, it would be ideal for the cholesterol value not to exceed 200 mg/dL and HDL cholesterol to be above 40 mg/dL in men and above 50 mg/dL in women [10].

2. Materials and methods

When the patient presents himself to the laboratory and requests the performance of medical analyses it is good to be informed about the conditions that must be met to obtain results precise about his health condition. That is why he will maintain an unchanged diet for a long time of three weeks before harvest as well as a stable weight. Must not consume food 12-16 hours before investigations and no alcohol 72 hours before collection. It's good to find out, if possible, if the patient has a pathological history or if he has signs and symptoms that led him to perform these laboratory investigations to be informed if other additional analyses are needed to help him discover possible causes and conditions [11].

Blood samples are collected in red or yellow vacutainer systems for biochemistry, without additives, volume 6 mL, with or without separating gel. Collected blood samples are identified with barcodes, with names the patient, sit on the stands and get ready to work. It should be noted that tourniquet pressure prolonged over 2 minutes increases the value of cholesterolemia by 2-5%. Variations in cholesterol values are also associated with the season (higher values in winter by up to 8%), with medications, age and sex [12].

Cobas Integra 400 Plus (Figure 2) is a biochemistry device designed for a strengthen testing and increase the efficiency of investigational biological fluid testing. It has a patented design and sophisticated software programs to simplify the difficulty of working in laboratory.

Fig. 2. *Cobas Integra 400 Plus*

Reagents are incorporated into Cobas packs and STATs are automatically given up to 800 determinations/sample by automatic barcode reading. The on-board reagent has high stability from 8-12 weeks; thus, a reduced number of calibrations will be performed and will produce small amounts of resulting waste.

Quality control charts are run daily at the beginning of the analysis investigation process. For variable data, the diagrams are taken in pairs where the control limits are highlighted over time by adding two horizontal lines: the upper one (LCS) and the lower one (LCI) (Figure 3). Device calibrations are presented in Figures 4-8.

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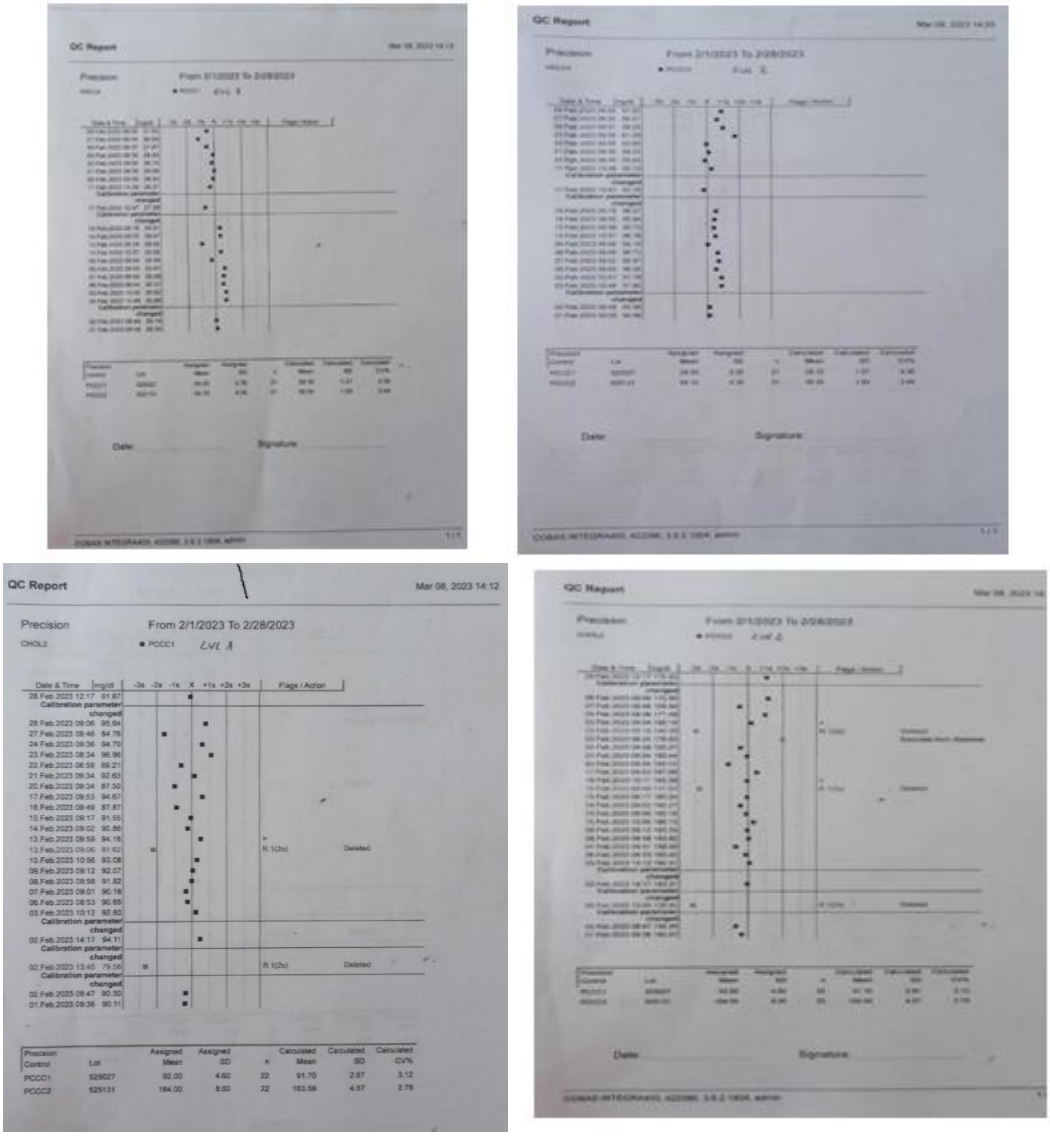

Fig. 3. *Quality control charts*

Fig. 4. *Control of the device before starting the activity. Liquid waste check*

Fig. 5. *Solid waste box*

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Fig. 6. *Calibration control*

Fig. 7. Test control and level of ionic solutions

Fig. 8. *Cholesterol and HDL cholesterol control reagent boxes*

3. Results and Discussion

Different outcomes were determined such as basic biochemical parameters (total cholesterol, HDL cholesterol, LDL cholesterol), were analysed in serum by standard biochemical procedures, using the automatic analyser Cobas Integra 400 Plus by the spectrophotometric method.

Table 1 show the normal and pathological values of the lipid profile, the risk factors involved in the processes favouring cardiovascular and nutritional diseases. During life, these factors become modifiable and non-modifiable for various conditions [13, 14].

The normal values (Fig. 9) are made for a male patient with no history of chronic diseases, and it is observed that the values of total cholesterol and its two subdivisions HDL cholesterol and LDL cholesterol are within normal limits.

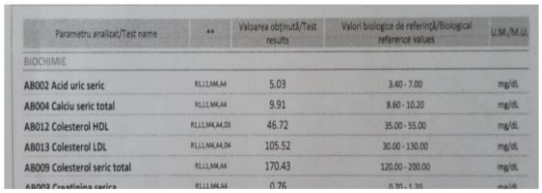

Fig. 9. *Normal values*

Figures 10-13 shows the results of the analyses (normal lipid profile) with parameters within normal limits, for different patients such as gender and age, but with present pathologies.

Table 1. *Representation of lipid profile values*

Lipid profile	Normal values, mg/dL	Limit values, mg/dL	Values above the normal limit, mg/dL	Risk values	Remarks
Total lipids	400 - 750				LT = 2,25 x total cholesterol + 90
Triglycerides	50 – 150	151 - 200	< 200	Over 500	
Fatty acids	200 – 450				Acid values > reference range = lipolytic answer
Lipoproteins	150 - 200				
Total cholesterol	< 200	200 - 339	< 240		
HDL cholesterol	> 40 (increased risk of atherosclerosis)	39	≤ 60 (decreased risk of atherosclerosis)		
LDL cholesterol	< 130	130 - 159	160 – 189	≤ 190	LDL = total cholesterol – HDL cholesterol
VLDL colesterol	2 - 38				VLDL = TG/5

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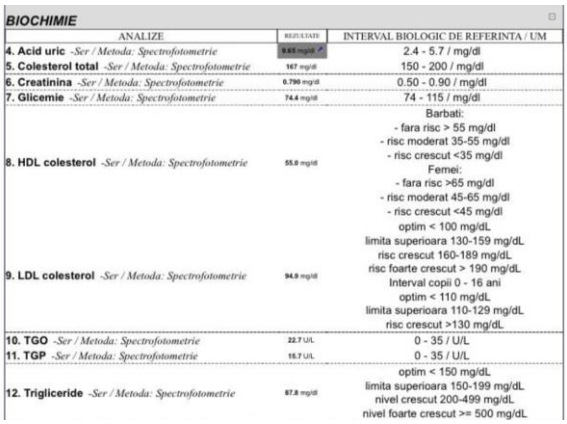
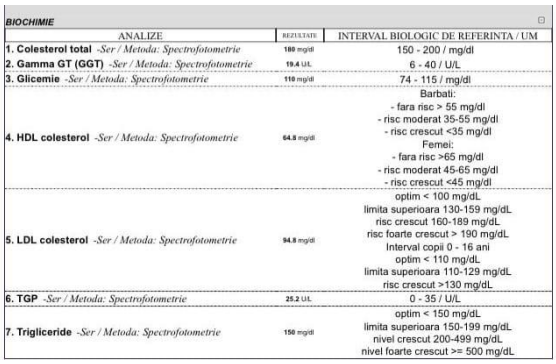
52-year-old man known to have type II diabetes, routine tests have the result total cholesterol and fractions of LDL and HDL cholesterol within normal limits (total cholesterol -167 mg/dL, HDL cholesterol -55.0 mg/dL, LDL cholesterol -94.9 mg/dL) (Figure 10).



BIOCHIMIE		
ANALIZE	REZULTATE	INTERVAL BIOLOGIC DE REFERINTA / UM
4. Acid uric -Ser / Metoda: Spectrofotometrie	9.65 mg/dl	2.4 - 5.7 / mg/dl
5. Colesterol total -Ser / Metoda: Spectrofotometrie	167 mg/dl	150 - 200 / mg/dl
6. Creatinina -Ser / Metoda: Spectrofotometrie	0.790 mg/dl	0.50 - 0.90 / mg/dl
7. Glicemie -Ser / Metoda: Spectrofotometrie	74.4 mg/dl	74 - 115 / mg/dl
8. HDL colesterol -Ser / Metoda: Spectrofotometrie	55.0 mg/dl	Barbati: - fara risc > 55 mg/dl - risc moderat 35-55 mg/dl - risc crescut <35 mg/dl Femei: - fara risc >65 mg/dl - risc moderat 45-65 mg/dl - risc crescut <45 mg/dl
9. LDL colesterol -Ser / Metoda: Spectrofotometrie	94.9 mg/dl	optim < 100 mg/dL limita superioara 130-159 mg/dL risc crescut 160-189 mg/dL risc foarte crescut > 190 mg/dL Interval copii 0 - 16 ani optim < 110 mg/dL limita superioara 110-129 mg/dL risc crescut >130 mg/dL
10. TGO -Ser / Metoda: Spectrofotometrie	22.7 U/L	0 - 35 / U/L
11. TGP -Ser / Metoda: Spectrofotometrie	15.7 U/L	0 - 35 / U/L
12. Trigliceride -Ser / Metoda: Spectrofotometrie	87.8 mg/dl	optim < 150 mg/dL limita superioara 150-199 mg/dL nivel crescut 200-499 mg/dL nivel foarte crescut >= 500 mg/dL

Fig. 10. *Normal result for a patient with diabetes*

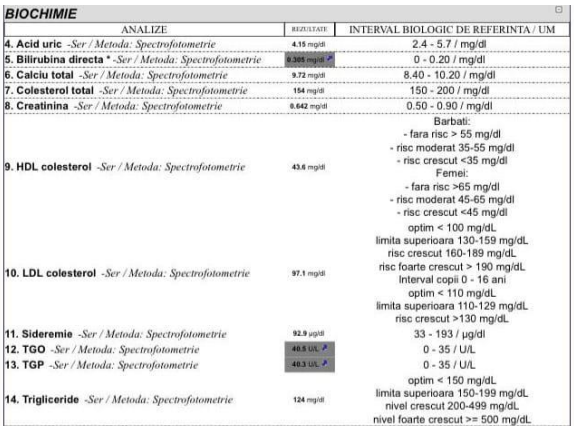
37-year-old woman, (total cholesterol -180 mg/dL, HDL cholesterol 64.8 mg/dL, LDL cholesterol -94.8 mg/dL) with conditions thyroid (Figure 11).



BIOCHIMIE		
ANALIZE	REZULTATE	INTERVAL BIOLOGIC DE REFERINTA / UM
1. Colesterol total -Ser / Metoda: Spectrofotometrie	180 mg/dl	150 - 200 / mg/dl
2. Gamma GT (GGT) -Ser / Metoda: Spectrofotometrie	19.4 U/L	6 - 40 / U/L
3. Glicemie -Ser / Metoda: Spectrofotometrie	110 mg/dl	74 - 115 / mg/dl
4. HDL colesterol -Ser / Metoda: Spectrofotometrie	64.8 mg/dl	Barbati: - fara risc > 55 mg/dl - risc moderat 35-55 mg/dl - risc crescut <35 mg/dl Femei: - fara risc >65 mg/dl - risc moderat 45-65 mg/dl - risc crescut <45 mg/dl
5. LDL colesterol -Ser / Metoda: Spectrofotometrie	94.8 mg/dl	optim < 100 mg/dL limita superioara 130-159 mg/dL risc crescut 160-189 mg/dL risc foarte crescut > 190 mg/dL Interval copii 0 - 16 ani optim < 110 mg/dL limita superioara 110-129 mg/dL risc crescut >130 mg/dL
6. TGP -Ser / Metoda: Spectrofotometrie	25.2 U/L	0 - 35 / U/L
7. Trigliceride -Ser / Metoda: Spectrofotometrie	150 mg/dl	optim < 150 mg/dL limita superioara 150-199 mg/dL nivel crescut 200-499 mg/dL nivel foarte crescut >= 500 mg/dL

Fig. 11. *Normal result for a patient with autoimmune thyroiditis*

49-year-old female known to have chronic liver disease, although transaminase results are modified, cholesterol and its fractions are within normal limits (total cholesterol -154 mg/dL, HDL cholesterol 43.6 mg/dL, LDL cholesterol -97.1 mg/dL), liver functions should be monitored further and administration treatment according to the specialist doctor's recommendations (Figure 12).

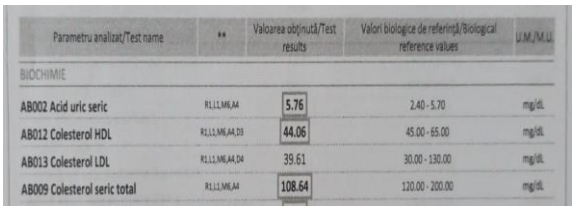


BIOCHIMIE		
ANALIZE	REZULTATE	INTERVAL BIOLOGIC DE REFERINTA / UM
4. Acid uric -Ser / Metoda: Spectrofotometrie	4.15 mg/dl	2.4 - 5.7 / mg/dl
5. Bilirubina directa * -Ser / Metoda: Spectrofotometrie	0.305 mg/dl	0 - 0.20 / mg/dl
6. Calciu total -Ser / Metoda: Spectrofotometrie	9.72 mg/dl	8.40 - 10.20 / mg/dl
7. Colesterol total -Ser / Metoda: Spectrofotometrie	154 mg/dl	150 - 200 / mg/dl
8. Creatinina -Ser / Metoda: Spectrofotometrie	0.642 mg/dl	0.50 - 0.90 / mg/dl
9. HDL colesterol -Ser / Metoda: Spectrofotometrie	43.6 mg/dl	Barbati: - fara risc > 55 mg/dl - risc moderat 35-55 mg/dl - risc crescut <35 mg/dl Femei: - fara risc >65 mg/dl - risc moderat 45-65 mg/dl - risc crescut <45 mg/dl
10. LDL colesterol -Ser / Metoda: Spectrofotometrie	97.1 mg/dl	optim < 100 mg/dL limita superioara 130-159 mg/dL risc crescut 160-189 mg/dL risc foarte crescut > 190 mg/dL Interval copii 0 - 16 ani optim < 110 mg/dL limita superioara 110-129 mg/dL risc crescut >130 mg/dL
11. Sideremie -Ser / Metoda: Spectrofotometrie	92.9 µg/dl	33 - 193 / µg/dl
12. TGO -Ser / Metoda: Spectrofotometrie	40.5 U/L	0 - 35 / U/L
13. TGP -Ser / Metoda: Spectrofotometrie	40.3 U/L	0 - 35 / U/L
14. Trigliceride -Ser / Metoda: Spectrofotometrie	124 mg/dl	optim < 150 mg/dL limita superioara 150-199 mg/dL nivel crescut 200-499 mg/dL nivel foarte crescut >= 500 mg/dL

Fig. 12. *Normal result for patient with chronic liver disease*

The results of the validated samples are continuously transmitted to the LIS (the system computer science from the laboratory) through the communication mode with host query.

Pathological results that indicate various conditions and are obtained from harvesting of patients with confirmed diagnoses of dyslipidemia are presented in Figure 13.



Parametru analizat/Test name	**	Valoarea obținută/Test results	Valori biologice de referință/Biological reference values	U.M./M.U.
BIOCHIMIE				
AB002 Acid uric seric	R1,L1,M6,A4	5.76	2.40 - 5.70	mg/dL
AB012 Colesterol HDL	R1,L1,M6,A4,D3	44.06	45.00 - 65.00	mg/dL
AB013 Colesterol LDL	R1,L1,M6,A4,D4	39.61	30.00 - 130.00	mg/dL
AB009 Colesterol seric total	R1,L1,M6,A4	108.64	120.00 - 200.00	mg/dL

Fig. 13. *Pathological result*

HDL cholesterol has the role of transporting other forms of lipids and cholesterol through the blood to the liver where they are synthesized and eliminated. The higher the number of its value, the better it is for the human body.

When the level of HDL cholesterol is low for various reasons, the transport of fats can no longer be carried out at the same standards and then their excess is deposited on the blood vessels, forming atheroma plaques. Also, the arteries narrow, and blood flow is limited, accelerating the risk of developing atherosclerosis.

72-year-old man with dyslipidemia, diabetes and renal impairment. The patient must medically monitored and re-evaluation of additional cardiological investigations, dietary regimen. (total cholesterol -206 mg/dL, HDL cholesterol -37 mg/dL, LDL cholesterol -126 mg/dL, triglycerides-231 md/dL).

It can be observed that the HDL cholesterol value is at the lower limit and the LDL cholesterol at

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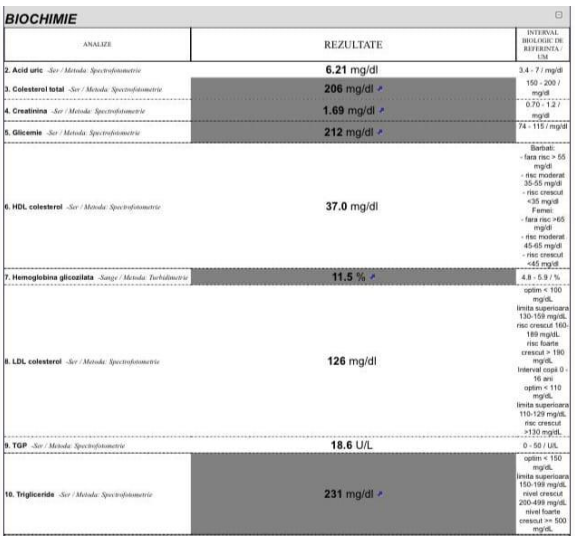
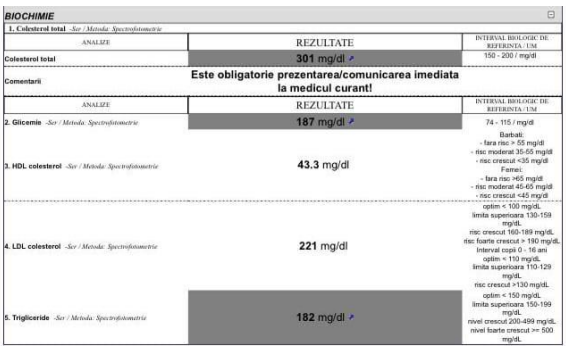
the limit higher, which means that there is a possibility of developing cardiovascular diseases (Figure 14).



BIOCHIMIE		
ANALIZE	REZULTATE	INTERVAL BIOLOGIC DE REFERINTA / UM
2. Acid uric -Ser / Metoda: Spectrofotometrie	6.21 mg/dl	3.4 - 7 / mg/dl
3. Colesterol total -Ser / Metoda: Spectrofotometrie	206 mg/dl	150 - 200 / mg/dl
4. Creatinina -Ser / Metoda: Spectrofotometrie	1.69 mg/dl	0.70 - 1.2 / mg/dl
5. Glicemie -Ser / Metoda: Spectrofotometrie	212 mg/dl	74 - 115 / mg/dl
6. HDL colesterol -Ser / Metoda: Spectrofotometrie	37.0 mg/dl	Barbati: - fara risc > 55 mg/dl - risc moderat 35-55 mg/dl - risc crescut <35 mg/dl Femei: - fara risc >65 mg/dl - risc moderat 45-65 mg/dl - risc crescut <45 mg/dl
7. Hemoglobina glicozilata -Sange / Metoda: Turbidimetrie	11.5 %	4.8 - 5.9 / %
8. LDL colesterol -Ser / Metoda: Spectrofotometrie	126 mg/dl	optim < 100 mg/dL limita superioara 130-159 mg/dL risc crescut 160-189 mg/dL risc foarte crescut > 190 mg/dL Interval copii 0 - 16 ani optim < 110 mg/dL limita superioara 110-129 mg/dL risc crescut >130 mg/dL
9. TGP -Ser / Metoda: Spectrofotometrie	18.6 U/L	0 - 50 / U/L
10. Trigliceride -Ser / Metoda: Spectrofotometrie	231 mg/dl	optim < 150 mg/dL limita superioara 150-199 mg/dL nivel crescut 200-499 mg/dL nivel foarte crescut >= 500 mg/dL

***Fig. 14**. Pathological result*

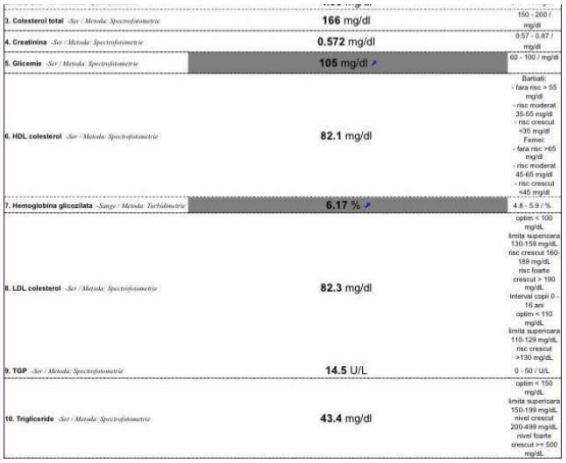
Male patient, 49 years old, with insulin-dependent diabetes mellitus, obesity, dyslipidemia, high-risk hypertension, chronic ischemic heart disease-with increased values of total cholesterol-301 mg/dL, LDL cholesterol-221 mg/dL, HDL cholesterol at the lower limit 43.3 mg/dL. It is in the records of specialist doctors with established treatment, diet and regimen hyposodium, hypocaloric and periodic medical reassessment (electrocardiogram, coronary angiography, investigations biological, nuclear magnetic resonance) (Figure 15).



BIOCHIMIE		
1. Colesterol total -Ser / Metoda: Spectrofotometrie		
ANALIZE	REZULTATE	INTERVAL BIOLOGIC DE REFERINTA / UM
Colesterol total	301 mg/dl	150 - 200 / mg/dl
Comentarii	Este obligatorie prezentarea/comunicarea imediata la medicul curant!	
ANALIZE	REZULTATE	INTERVAL BIOLOGIC DE REFERINTA / UM
2. Glicemie -Ser / Metoda: Spectrofotometrie	187 mg/dl	74 - 115 / mg/dl
3. HDL colesterol -Ser / Metoda: Spectrofotometrie	43.3 mg/dl	Barbati: - fara risc > 55 mg/dl - risc moderat 35-55 mg/dl - risc crescut <35 mg/dl Femei: - fara risc >65 mg/dl - risc moderat 45-65 mg/dl - risc crescut <45 mg/dl
4. LDL colesterol -Ser / Metoda: Spectrofotometrie	221 mg/dl	optim < 100 mg/dL limita superioara 130-159 mg/dL risc crescut 160-189 mg/dL risc foarte crescut > 190 mg/dL Interval copii 0 - 16 ani optim < 110 mg/dL limita superioara 110-129 mg/dL risc crescut >130 mg/dL
5. Trigliceride -Ser / Metoda: Spectrofotometrie	182 mg/dl	optim < 150 mg/dL limita superioara 150-199 mg/dL nivel crescut 200-499 mg/dL nivel foarte crescut >= 500 mg/dL

***Fig. 15**. Pathological result*

In Figure 16 it was presented a result from a 14-year-old male patient with obesity, diabetes mellitus type I, insulin-dependent.



3. Colesterol total -Ser / Metoda: Spectrofotometrie	166 mg/dl	150 - 200 / mg/dl
4. Creatinina -Ser / Metoda: Spectrofotometrie	0.572 mg/dl	0.57 - 0.87 / mg/dl
5. Glicemie -Ser / Metoda: Spectrofotometrie	105 mg/dl	60 - 100 / mg/dl
6. HDL colesterol -Ser / Metoda: Spectrofotometrie	82.1 mg/dl	Barbati: - fara risc > 55 mg/dl - risc moderat 35-55 mg/dl - risc crescut <35 mg/dl Femei: - fara risc >65 mg/dl - risc moderat 45-65 mg/dl - risc crescut <45 mg/dl
7. Hemoglobina glicozilata -Sange / Metoda: Turbidimetrie	6.17 %	4.8 - 5.9 / %
8. LDL colesterol -Ser / Metoda: Spectrofotometrie	82.3 mg/dl	optim < 100 mg/dL limita superioara 130-159 mg/dL risc crescut 160-189 mg/dL risc foarte crescut > 190 mg/dL Interval copii 0 - 16 ani optim < 110 mg/dL limita superioara 110-129 mg/dL risc crescut >130 mg/dL
9. TGP -Ser / Metoda: Spectrofotometrie	14.5 U/L	0 - 50 / U/L
10. Trigliceride -Ser / Metoda: Spectrofotometrie	43.4 mg/dl	optim < 150 mg/dL limita superioara 150-199 mg/dL nivel crescut 200-499 mg/dL nivel foarte crescut >= 500 mg/dL

***Fig. 16.** Results for a child with obesity*

As it can be observed in the presented results, the patients of different ages suffer from associated diseases, due to the increase in the value of cholesterol and must be considered assessment of established or emerging cardiovascular disease risks and investigation the risk of atheromatosis, which favours stroke.

4. Conclusions

The study briefly outlines the links between cholesterol, obesity and genetic factors, describing dyslipidemia and risk factors.

The case study summarized the results of some patients with the following medical conditions: disorders lipid metabolism, diabetes, kidney disorder, thyroid disease, obesity, hypertension, chronic liver disorder, ischemic heart disease.

Total cholesterol values between 154-301 mg/dL are observed, which reveals that these patients are at risk of dyslipidemia diagnosis if they have not already received specialist confirmation.

In the case of HDL cholesterol, it was found that the determined limit values are from 37 mg/dL to 64.8 mg/dL, which shows a potential pathological risk factor. For LDL cholesterol, the obtained results reveal limits of 94.8 mg/dL, respectively 221 mg/dL - which determines increased cardiovascular risks.

HDL cholesterol has the role of transporting other forms of lipids and cholesterol through the blood to the liver where they are synthesized and eliminated. The higher the number of its value, the better it is for organism. When the level of HDL cholesterol is low for various reasons, the transport of fats can no longer be carried out at the same standards and then their excess is deposited on the blood vessels forming atheroma plaques. Also, the arteries narrow, and the blood flow is limited, accelerating the risk of developing atherosclerosis, which favours stroke.

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Patients will be monitored from a medical point of view and periodically reevaluated, recommending additional cardiological investigations, as well as a dietary regimen. The investigation of serum lipids provides information regarding the analysed limits specific to age, sex, and pathology.

The data obtained in the study will be used for preventive purposes. Regular checking of biological parameters, healthy diet and physical activities are the main ways to keep cholesterol levels under control.

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