

## SUDDEN CARDIAC DEATH IN YOUNG PEOPLE – FORENSIC MEDICAL RELEVANCE

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**ABSTRACT.** In accordance with the forensic criteriology, but also juridical, death can be defined as the physiological process triggered by violent or non-violent causes and characterized with the ceasing of vital functions, which causes the formation of the irreversible damage to the central nervous system, and finally, the disappearance of the individual as a biological entity. The non-violent death is the death which is produced without violating the right to life of the human being and without the intervention of a traumatic agent outside the body. Sudden death is included in the category of deaths suspected of being violent. According to the recent specialized data, numerous cardiac conditions with identifiable correspondent within the histopathological microscopic exam, situated at the origin of cardiac sudden death are genetically determined. In the category of sudden deaths, the most common are those of cardiac origin (approximately 80%, most of the victims being males – approximately 70-75%). In the study were examined the permanent histological preparations obtained from 347 of forensic autopsies. From these, 201 (57.92%) were cases of violent death, and 146 (42.07%) were cases of non-violent death. From the cases of non-violent death, 14 have been of cardiac origin, in which case death occurred before the age of 45 years. The histopathological elements followed were: early myocardial ischemia, acute myocardial heart failure, acute endocarditis, acute myocarditis and acute pancarditis (acute organic diseases which may cause sudden death) and coronary atherosclerosis, myocardosclerosis, myocardofibrosis, subepicardic myocardial lipomatosis (chronic organic lesions which through decompensation may cause sudden death). In the same study, is currently ongoing genetic tests (the sequencing stage) for identifying the mutations likely to be involved in the tanato-generator mechanism of sudden death of cardiac origin; the DNA sources used being represented by the histopathology preparations archived (paraffin blocks) from the cases which were examined microscopically. The correlation of the tanato-generator histopathological elements identifiable microscopically, (coronary atherosclerosis, subepicardic myocardial lipomatosis, myocardofibrosis, myocardosclerosis, acute myocarditis, acute endocarditis, pancarditis, heart failure) with the results of the genetic tests will allow to register timely therapeutically the relatives of the victims of sudden cardiac death for the prevention of other deaths.

**Keywords:** sudden cardiac death, forensic, pathology

### INTRODUCTION

Life and death are two aspects of the same reality, interrelated sides of existential dualism.

Defining death, considered as a dark and cryptic side of existential binomial (in which participates along with life), encounters difficulties, until now it could not be made a definition that includes all scientific, religious and social aspects of this phenomenon. From the forensic and legal perspective, death or abiosis can be defined as a physiological process triggered by violent or non-violent causes, characterized by cessation of vital functions (cardio-circulatory and respiratory), which brings irreversible damage to the nervous system, with cessation of brain functions, including the brain stem, and finally to the disappearance of the individual as biological entity. Simplifying, death signifies the end of life. From the perspective of biomedical sciences, life or biosis is considered superior form of motion of matter, representing a synthesis of all mechanical processes, physical and chemical processes occurring in the body and is characterized by metabolism, self-reproduction,

reactivity/excitability, variability and development. In terms of forensic and legal terms, death can be of violent or nonviolent etiology.

Nonviolent death is death that occurs without violating the right to life of the human being and without the intervention of an external traumatic agent, determined solely by internal causes, nonviolent death can be:

- natural (death “of old age”) - which occurs in old age through the physiological process of body aging (the limit of obsolescence, genetically planned for the human being would be at about 115 years, due to the depletion of the 50 divisions, the human embryonic cells are capable of), is an exceptionally rare situation (Jeanne Calmet died on 08.04.1997 in the French city of Arles, at the age of 122 years), because most times, in death determinism, an illness or injury occurs.
- pathological - death as the final event of a condition or organic disease is the most common type of death, pathological death can occur slowly (after

lengthy hospitalization for malignancy, tuberculosis, liver cirrhosis etc.) or fast (myocardial infarction, cerebral infarction etc.).

- Suspected to be violent is the death which lies at the boundary between the two types of death, diametrically opposed (violent and nonviolent). Due to causes and conditions / circumstances that produce it, death suspected to be violent may be included (without performing the autopsy) in either the group of violent deaths or the non-violent. The category of deaths suspected to be violent includes also sudden death. Depending on the macroscopic aspect detected at autopsy, sudden death may present under several aspects:
- sudden death with organic lesions incompatible with survival: myocardial infarction with myocardial rupture, cerebral hemorrhage, bronchopneumonia, sepsis, hemorrhagic pancreatitis, malignancy, etc.
- sudden death with chronic organic damage: coronary atherosclerosis, myocardial fibrosis, myocardial sclerosis, asthma, pulmonary sclerosis etc. . In such cases, at autopsy, the coroner will highlight the organic pathological background, but will not make judgments on situations that have overloaded vital functions if from the available survey data cannot be deducted the circumstances in which the person's death has occurred.
- sudden death with nonspecific organic changes (generalized visceral stasis, pulmonary emphysema, suffusions blood, cyanosis, etc.) for a certain disease, common to both violent and nonviolent deaths, in which case the type and cause of death will be determined only after forensic autopsy and laboratory complex thanatological examinations (microscope, toxicological, serological, etc.) whose results must be correlated with survey data.

In the category of sudden death (death suspected to be violent) the most common are those of cardiac origin (around 80 %, with most victims being males - about 70-75 %).

The European Society of Cardiology defines sudden cardiac death (SCD) as “ natural death due to cardiac causes, heralded by abrupt loss of consciousness within one hour from acute symptom onset; pre-existing heart disease can be known, but the time and mode of death are unexpected”. Fundamental concepts underlying the basic definition of sudden death are the non-traumatic nature of the event and the fact that death must be unexpected and instantaneous.

In the world of the living, the cell is the basic unit which performs all the processes that maintain life. A mature human body is composed of several thousand of millions of cells which are derived from the same cell – the egg cell. Having a common origin, all cells of an organism contain the same genetic material, localized predominantly in the cell nucleus and only a little extranuclear in mitochondria (only about 0.5 %). The genetic information is concentrated in the cell

nucleus in the DNA molecule. With the exception of red blood cells and platelets (thrombocytes), which are devoid of the core, the DNA molecule is found in all other cells. The DNA molecule is entered in coded form the genetic message, whose expression determines the development of the body and gives biological individuality. The set of genetic information specific to the body defines the human genome.

According to Hoffman's study, in 50-60 % cases of sudden cardiac death in children are found genetic heart disease. English and Dutch studies show that between 22-28 % of first degree relatives of SIDS (sudden infant death syndrome) carry a hereditary heart disease.

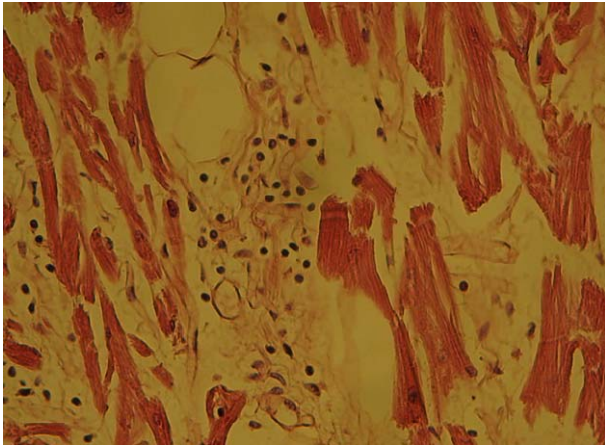
Sudden cardiac death may occur due to genetic abnormalities that affect key proteins of the myocardium. Genetic mutations are changes that occur in the genes of the chromosome or other cellular constituents carriers of heredity, so changes in the genotype. Depending on the substrate they affect, mutations can in turn be divided into gene mutations, chromosomal, genomic or plastid ones. Mutations can occur due to the action on the genome of physical, chemical or biological factors. Mutations transmitted from parents to the child are called hereditary mutations or germline mutations because they are present in germ cells and will be present in every cell in the body of the affected person. Mutations that occur only after fertilization are called new mutations. New mutations may explain genetic disorders where a child has a mutation in every cell, but has no other cases like this in the family. Acquired or somatic mutations appear in the DNA of individual cells in a specific stage of the life of an individual. The causes of these changes may be environmental factors or may occur if an error appears in DNA copies during cell division. Acquired mutations in somatic cells cannot be transferred from generation to generation. Conditions such as Long QT syndrome, Brugada Syndrome, obstructive hypertrophic cardiomyopathy, right ventricular cardiomyopathy, Catecholaminergic polymorphic ventricular tachycardia and dilated cardiomyopathy are the most common monogenic diseases predisposing to sudden cardiac death. Existing evidence supporting the existence of genetic predisposition to sudden cardiac death was also evaluated, non-correlated with a monogenic disease. Evidence supporting the existence of a “genetic susceptibility factor” that predisposes to sudden cardiac death have emerged from widespread epidemiological studies that have demonstrated familial association in sudden cardiac death. Family environment, including “diet, psychological and development factors” may all play a part in determining susceptibility clustered in family members. Genetic testing of biological material collected postmortem and correlation between the outcome of their examination result and the result of macroscopic examination, microscopic and toxicological analysis can help to explain the

tanatogenerative mechanism in a multidisciplinary collaboration.

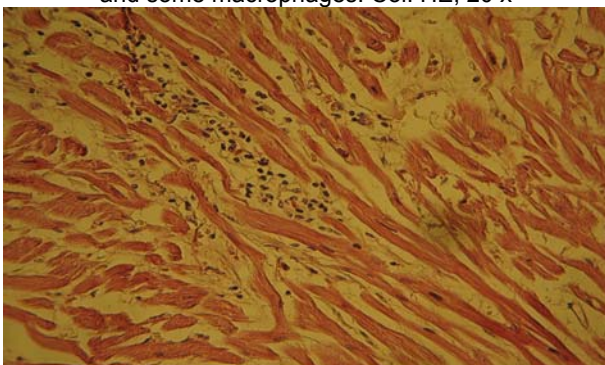
### MATERIALS AND METHODS

Permanent histopathological preparations were studied, obtained from 347 forensic autopsies performed in 2012 in the Arad County Service of Forensic Medicine. Out of these, 201 (57.92 %) were cases of violent death, while 146 (42.07 %) were non-violent deaths. From the nonviolent deaths we have selected a sample of 14 cases of sudden cardiac death, where the death occurred before the age of 45 years. Histopathological technique used: 10% formaldehyde fixing solution (buffered with calcium carbonate), washing, drying (acetone or alcohol), toluene clarification, impregnation with paraffin microtome sectioning the wax ribbon scope of the flotation bath, and determining the blade (previously greased with albumin Mayer), drying and de-waxing plateau thermostated baths toluene dewaxing, dehydration in alcohol baths, HE staining, dehydration with alcohol,

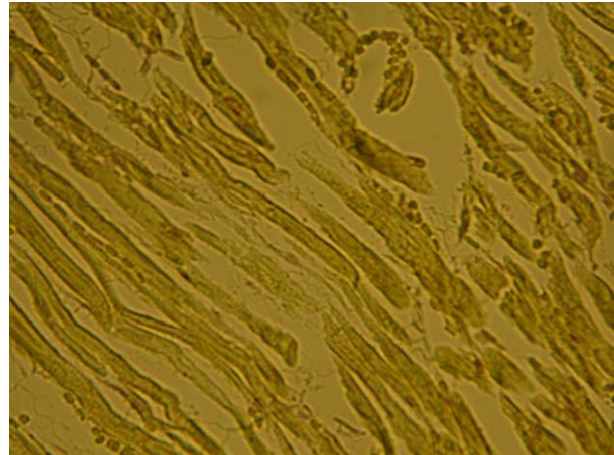
toluene clarification, blades installing (Canada balsam or Entellan). Microscopic histopathological elements were: early myocardial ischemia, myocardial infarction, acute endocarditis, acute myocardial infarction and boards (acute organic disease that can cause sudden death) and coronary atherosclerosis, myocardial sclerosis, myocardial fibrosis, subepicardial myocardial lipomatosis (chronic organ damage by decompensation may cause sudden death). For early diagnosis of myocardial ischemia in the early stages special staining method Lie was used: dewaxing and regressive gradual hydration in alcoholic solutions, staining 15 seconds in the R-1 (hematoxylin), rinsing with distilled water, dye 3 minutes. R -2 (basic fuchsin), rinsing with distilled water, acetone clarification, differentiation picric acid -acetone R -3 until the red color of the fund decreases, washing with acetone R-4, progressive dehydration in alcohol solutions, clarification in xylene and mount-ing in balsam.



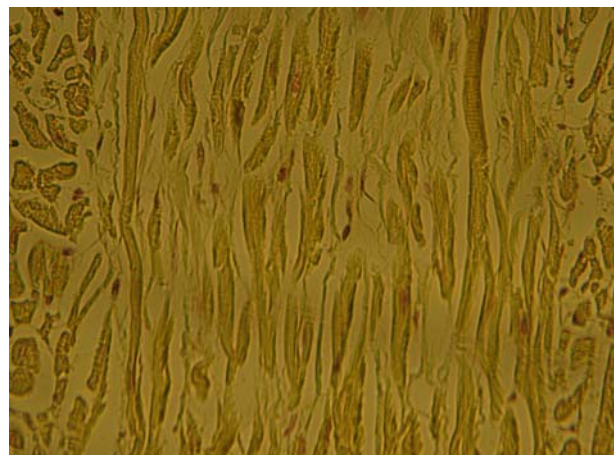
**Fig. 1.** Man aged 45 years, found dead in his home. Acute myocarditis: diffuse interstitial infiltration with lymphocytes and some macrophages. Col. HE, 20 x



**Fig. 3.** 35 year old man, deceased on the job. Outbreak of acute myocardial infarction. Col. HE, 20 x

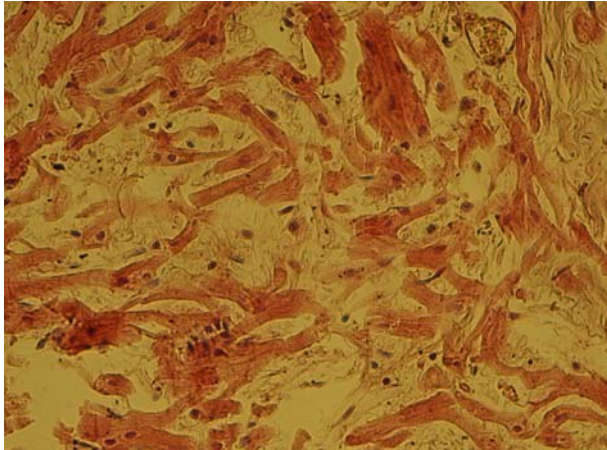


**Fig. 2.** 45 year old man, found dead in his home. Subendocardial myocardial ischemia

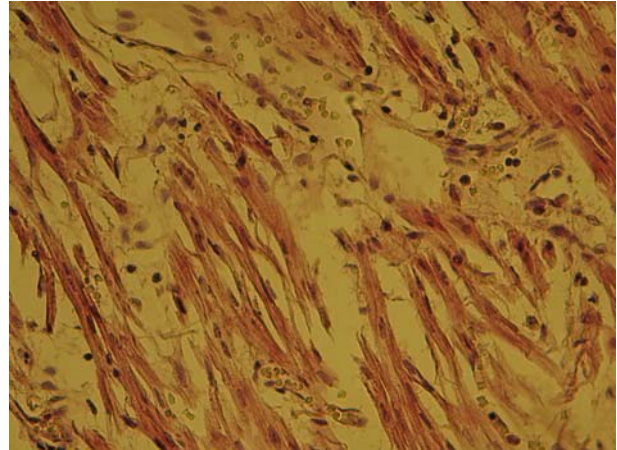


**Fig. 4.** Same case. Subendocardial ischemia. Col. Lie, 20 x

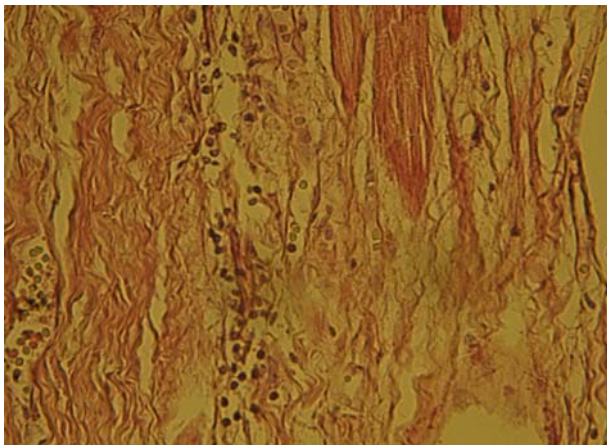




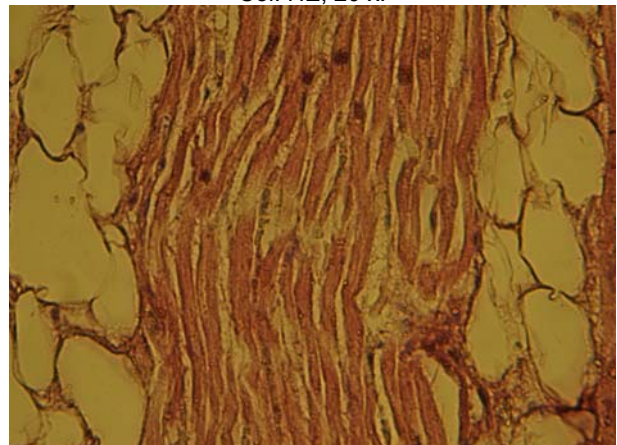
**Fig.5.** Man aged 37, found dead (early decay). Acute myocarditis; diffuse interstitial infiltration with lymphocytes and some macrophages. Col. HE, 20 x



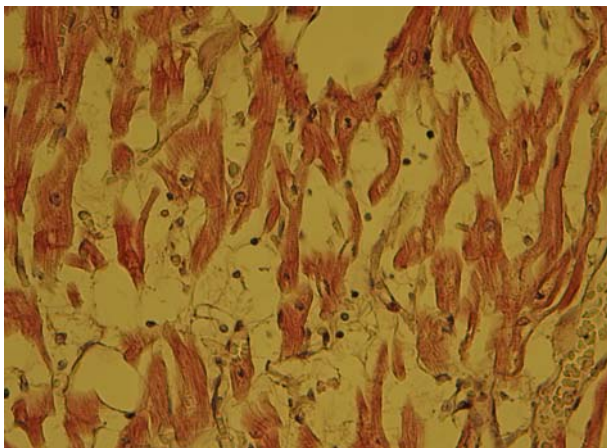
**Fig. 6.** 2 months old infant, male, found dead. Acute myocarditis: diffuse interstitial infiltration with lymphocytes and some macrophages and granulocytes. Col. HE, 20 x.



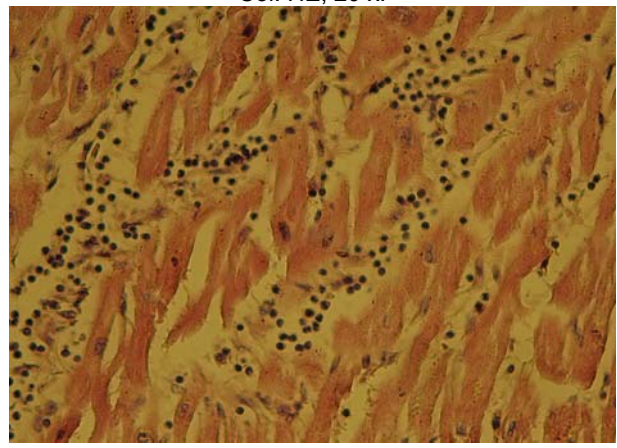
**Fig. 7.** Man aged 42, found dead (early decay). Myocardial infarction with granulation tissue outline. Col. HE, 20 x.



**Fig.8.** Man aged 44, found dead (advanced autolysis decaying areas). Subepicardial myocardial lipomatosis. Col. HE, 20 x.

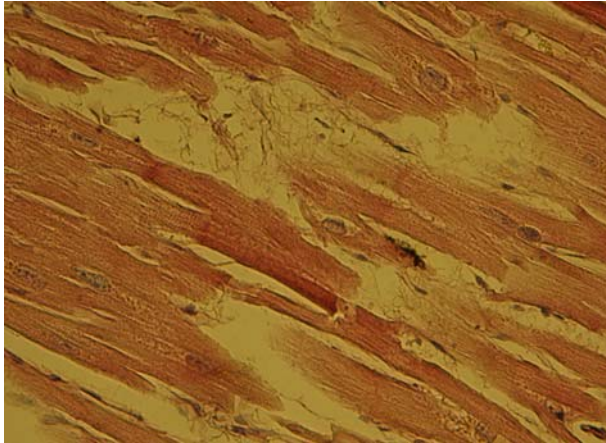


**Fig.9.** Man aged 44 years who died while en route to a medical facility for an appointment. Acute myocarditis on myocardial lipomatosis fund: moderate diffuse interstitial infiltration with lymphocytes and some macrophage. Col. HE, 20 x.

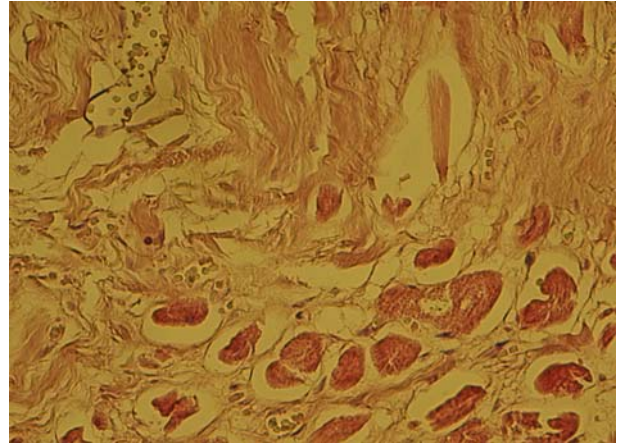


**Fig.10.** Female aged 42, found dead at home. Acute myocarditis: diffuse interstitial infiltrate with lymphocytes, granulocytes and some macrophages. Col HE, 20 x.

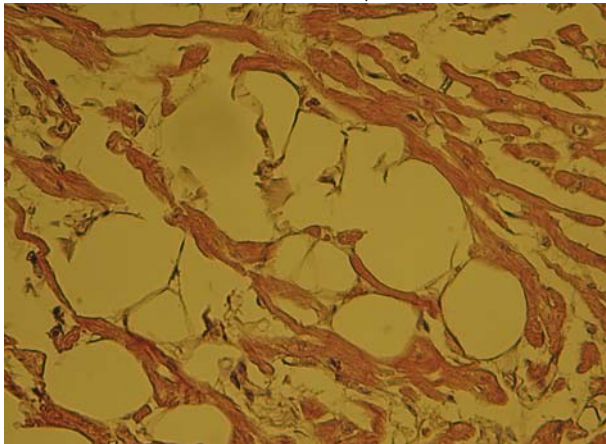




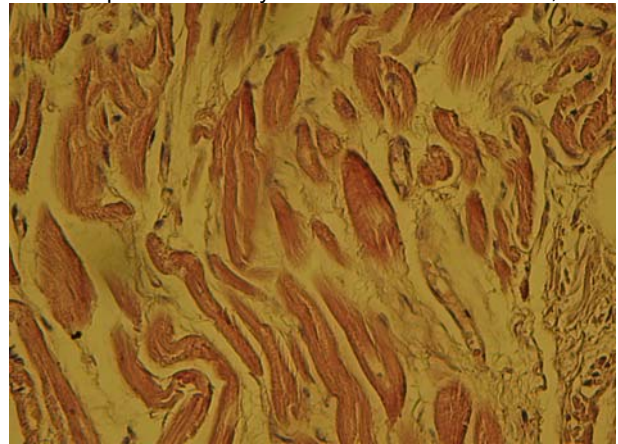
**Fig.11.** Man aged 40, found dead at home. Myocardial fibrosis. Col. HE, 20 x



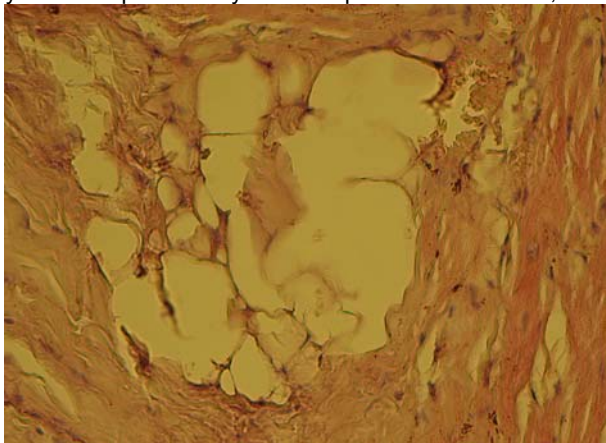
**Fig. 12.** Man aged 26, with chronic atrial fibrillation and external pacemaker. Myocardial sclerosis. Col. HE, 20 x



**Fig.13.** Man aged 37 years who died suddenly in his home yard. Subepicardic myocardial lipomatosis. Col. HE, 20 x



**Fig.14.** Man aged 41, found dead. Subendocardial myocardial fibrosis. Col. HE, 20 x



**Fig.15.** Man aged 44, found dead. Myocardial lipomatosis. Myocardial fibrosis. Col. HE, 20 x

## RESULTS AND DISCUSSIONS

Out of the 14 cases studied, 13 (92.85 %) were seen with the male sex, and one (7.14 %) for the female sex. The average age was approximately 37 years. Myocardial ischemia was diagnosed at an early stage in two cases (in the case of a man aged 45 years and for men 35 years, where he was diagnosed as a heart attack up). Myocardial infarction was diagnosed in two cases [acute myocardial infarction in man for 35 years (with acute subendocardial ischemia) and myocardial

infarction with granulation tissue for a man of 42 years]. Myocardial infarction was diagnosed in five cases (three men aged 45 years, 37 years and 44 years respectively, in the case of the infant aged two months and older for women 42 years). Myocardial fibrosis was diagnosed in three cases [man aged 40, a man aged 41 years and men aged 44 years (diagnosed and lipomatosis)]. Myocardial lipomatosis was diagnosed in four cases [man aged 44, a man aged 44 years (in the case which was diagnosed as a myocardial infarction),

a man aged 37 and a man aged 44 years (**diagnosed and miocardofibroza**]). Miocardoscleroza was diagnosed when 26 years young. Note that in two cases the diagnosis of myocardial infarction was determined microscopically: for the infant aged two months, where the macroscopic diagnosis was acute interstitial pneumonia and for a man aged 44 years at diagnosis myocardial infarction was macroscopically. It was not observed in all cases a direct correlation between coronary atherosclerosis and myocardial lipomatosis issues subepicardic, myocardial fibrosis and myocardial sclerosis.

## CONCLUSIONS

According to specialty recent data, numerous cardiac with identifiable correspondent within microscopic examination and histopathology with special stains commonly located at the origin of sudden cardiac death are genetically determined.

In terms of forensic is important that both tissue sources necessary for the histopathology microscopic examination of tissue and DNA sources that can be taken at autopsy may arise including the corpses burned and archived histological preparations. Genetic testing may be applied to all biological sample containing nucleated cells, the DNA macromolecule is very stable as compared with other protein molecules.

The possibility of carrying out genetic studies in forensic autopsies classified as negative or without any identified cause of death and correlation of tanatogenerative histopathological elements macroscopically and microscopically identifiable (coronary atherosclerosis, myocardial lipomatosis subepicardic, myocardial fibrosis, myocardial sclerosis, acute myocarditis, acute endocarditis, boards, myocardial infarction, etc.) with molecular autopsy results will allow a timely taking in evidence of the relatives of the sudden cardiac death victims in order to prevent other deaths.

## REFERENCES

- Veinot JP, Gattinger DA, Fliss H.: Early apoptosis in human myocardial infarcts. *Hum Pathol* 28(4):485-492. (1997)
- Narula, J et al.: Apoptosis in myocytes in end-stages heart failure, *N Engl J Med* 335(16):1182-1189. (1997)
- Chen, C si colab.: Myocardial cell death and apoptosis in hibernating myocardium *J Am Coll Cardiol* 30(5):1407-1412. (1997)
- Saraste A et al.: Apoptosis in human acute myocardial infarction. *Circulation* 95(2):320-323. (1997)
- Takemura G, Ohno M, Fujiwara H.: Ischemic heart disease and apoptosis. *Rinsho Byori* 45(7):606-613. (1997)
- Bardales RH, Hailey LS, Xie SS, Schaefer RF, HSu SM: In situ apoptosis assay for the detection of early acute myocardial infarction. *Am J Pathol* 149(3):821-829. (1996)
- Erlich JH, Boyle EM, Labriola J, Kovacich JC, Santucci RA, Fearn C, Morgan EN, Yun W, Luther T, Kojikawa O, Martin TR, Pohlman TH, Verrier ED, Mackman N: Inhibition of the tissue factor-thrombin pathway limits infarct size after myocardial ischemia-reperfusion injury by reducing inflammation. *Am J Pathol* 2000, 157:1849-1862
- Beranek JT: Thanatosomes and cardiomyocyte apoptotic bodies. *Hum Pathol* 2001, 32:894-895
- Beranek JT: Why primary angioplasty is less offensive to the myocardium compared with thrombolysis for acute myocardial infarction. *Am Heart J* 2000
- Beranek JT: Quick disposal of dead cardiomyocytes: an ultimate proof of their apoptosis. *J Heart Lung Transplant* 2001, 20:923-924
- Beranek JT: Pathogenesis of heart fibrosis in systemic sclerosis. *Int J Cardiol* 2001, 80:261-262
- Yin X-M., Dong Z.: *Essentials of Apoptosis – A Guide for Basic and Clinical Research*, Totowa, New Jersey, 2003
- Patrick A. Adegboyega MD, Abida K. Haque MD and Paul J. Boor MD: Extensive myocytolysis as a marker of sudden cardiac death, *Cardiovascular Pathology*, Vol. 5, Issue 6, 1996, Pages 315-321
- Kuo, H-C., Cheng, C-F., Clark, R.B., Lin, J.J-C., Lin, J.L-C., Hoshijima, M., Nguyen-Tran, van T.B., Gu, Y., Ross, Jr.J., Giles, W.R. and Chein, K.R.: A defect in the Kv channel-interacting protein 2 (KChIP2) gene leads to a complete loss of the transient outward potassium current (Ito) and confers genetic susceptibility to ventricular tachycardia. *Cell* 107:801-813. 2001.
- Blangy H, et. al.: Serum BNP, hs-C-reactive protein, procollagen to assess the risk of ventricular tachycardia in ICD recipients after myocardial infarction, *Europace*. 2007 Sep;9(9):724-9. Epub 2007 May
- Shaper AG, Wannamethee G, Macfarlane PW, Walker M. Heart rate, ischaemic heart disease, and sudden cardiac death in middle-aged British men. *Br Heart J* 1993; 70: 49-55. *Eur heart J*. Vol 22, issue 16, August 2001.
- Haider AW, Larson MG, Benjamin EJ, Levy D. Increased left ventricular mass and hypertrophy are associated with increased risk for sudden death. *J Am Coll Cardiol* 1998; 32: 1454-9.
- Kors JA, de Bruyne MC, Hoes Awet al. T-loop morphology as a marker of cardiac events in the elderly. *J Electrocardiol* 1998; 31(Suppl): 54-9.
- Burton F, Cobbe SM. Dispersion of ventricular repolarization and refractoriness. *Cardiovas Res* 2001; 50: 10-23.
- Elliot PM, Poloniecki J, Dickie S et al. Sudden death in hypertrophic cardiomyopathy: identification of high risk patients. *J Am Coll Cardiol* 2000; 36: 2212-6. Berger R.: *Circulation*. 2002; 105: 2392-2397.

- Veinot JP, Gattinger DA, Fliss H.: Early apoptosis in human myocardial infarcts. *Hum Pathol* 28(4): 485-492(1997).
- Sholler GF, Walsh EP. Congenital complete hearth block in patients without anatomic cardiac defects. *Am Hearth J* 1989; 118: 1193-8.
- Maron BJ. Sudden death in young athletes. Lesson from the Hank Gathers a. air. *N Engl J Med* 1993; 329: 55-7.
- Maron BJ. Cardiovascular risks to young person on the athletic field. *Ann Intern Med* 1998; 129: 378-86.
- Beranek JT: Pathogenesis of hearth fibrosis in systemic sclerosis. *Int J Cardiol* 2001, 80: 261-262.
- Blagy H, et al: Serum BNP, hs-C-reactive protein, procollagen to assess the risk of ventricular tachycardia in ICD recipients after myocardial infarction, *Europace*.2007 Sep; 9(9): 724-9.Epub 2007 May 24.
- Narula, J et al.: Apoptosis in myocytes in end-stages heart failure, *N Engl J Med* 335(16): 1182-1189(1997).
- Pfister GC, Pu.er JC, Maron BJ. Preparticipation cardiovascular screening for collegiate student-athletes. *JAMA* 2000; 283: 1597-9.
- Dermengiu D., Ceusu M., Rusu M.C., S. Dermengiu., Curcă G.C., Hostiuc S. Sudden death assdociated with borderline Hypertrophic cardiomiopathy and multiple coronary anomalies. Case report and literature review, *RJLM* vol. XVIII, nr. 1, march 2010, pg. 3-13.
- Michaud K., Lesta M.D.M., Fellman F., Mangin P., L'autopsie moleculaire de la mort subite cardiaque : de la salle d'autopsie au cabinet du praticien, *Revue Medicale Suisse*, 2 juillet 2008, no 164, vol 4, 1585-1632, ISSN 1660-9379.
- Beranek JT: Why primary angioplasty is less offensive to the myocardium compared with thrombolysis for acute myocardial infarction. *Am heart J* 2000.
- Myerburg, Robert J. „Cardiac Arrest and Sudden Cardiac Death” in *Heart Disease: A Textbook of Cardiovascular Medicine*, 7 thedition. Philadelphia: WB Saunders, 2005.
- Dermengiu Dan. *Curs de medicină legală*. Editura Viața Medicală Românească, București 2005, 26-53.
- Curcă GC, Drugescu N., Ardeleanu C., Ceaușu M.: Repere de investigare în moartea subită cardiacă la adultul tânăr, *Rom J LegMed* 16(1)57, 2008, 57-66.
- Robert J Myerburg, Agustin Castellanos: *Cardiac Arrest and Suden Cardiac Death*: 26; 890-909. 2001.
- Beliș V. : *Tratat de medicină legală*, 1995.
- Brinkmann B., Carracedo A. – (2003) *Progress in Forensic Genetics* 9, Excerpta Medica International Congress Series 1239, Elsevier, Amsterdam
- Covic M. și colab. – „*Genetica Medicală*”(2004) Edit.Polirom
- Emery A.E.H., Mueller R.F. - *Elements of MedicalGenetics*, 1992 Churchill Livingstone, LogmanGroup, Edinburg, 14
- Beliș V., Bărbării L. – *Genetica judiciară de la terorie la practică*, 2007
- Kendrew J. *DNA typing The Encyclopedia of Molecular Biology*, 1995, Blackwel Science Ltd., Oxford
- Kornelia Kotseva, David Wood, Guy de Backer – *Cardiovascular prevention quidelines in daily practice: a comparison of EuroAspire I, II and III surveys in eight European regions*. *Lancet* 2009; 373: 929-874
- Perk.J, Mathes P., Gohlke H., Mc.Gee H., Sellier P., Saner H. – *Cardiovascular Prevention and rehabilitation*. Springer-Verlag London 2007