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FORENSIC IDENTIFICATION OF SUDDEN CARDIAC DEATH DUE TO ALCOHOLIC CARDIOMYOPATHY

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Abstract. Alcohol is the most well-known toxic substance, the negative impact of which on human health and lifestyle is proven. Chronic alcoholism is a pathological condition that occurs after excessive alcohol consumption and can be observed in young and middle-aged men.

The aim of the study is to determine the characteristics of the age-sex distribution and pathomorphological changes of the heart and vessels in forensic cases of alcoholic cardiomyopathy (ACMP).

Material and methods. In our study, changes in the left ventricular myocardium due to alcohol consumption were investigated in 70 bodies of those who died at home under suspicious circumstances and were sent to the State Specialized Institution "Main Bureau of Forensic Medical Examination of the Ministry of Health of Ukraine" to determine the cause of death.

Bioethics. The study was conducted in accordance with the ethical principles set forth in the Declaration of Helsinki (1964) and subsequent amendments thereto. Ethical approval was obtained from the Committee on Ethics of Scientific Research, Experimental Developments and Scientific Works of the Danylo Halytskyi Lviv National Medical University (excerpt from protocol No. 14 dated December 20, 2023). All data were anonymized and processed in strict confidentiality to preserve the privacy of the deceased and their families.

Scientific research. "A study of pathogenetic mechanisms and pathomorphological features of endocrine, cardiovascular, respiratory, nervous, digestive, urinary, and reproductive systems and perinatal period diseases with the aim of improvement of their morphological diagnostics." Topic code: IN.07.00.0001.18. State registration number: 0122U201668

Results. The studied group with ACMP comprised 70 deceased people aged 16 to 40. Of these, 49 (70%) were aged 31 to 40. Of these, 51 (72.8%) were men, and 19 (27.2%) were women. Among the concomitant pathologies, chronic alcoholic hepatitis and hepatosis, as well as left-sided lower lobe bronchopneumonia, were detected in a third of cases. Additionally, in 8 (11.4%) cases, pulmonary embolism was found, associated with the presence of parietal thrombi. The final cause of death of the deceased was acute cardiac and cardiorespiratory failure, which arose as a result of heart damage. In 64.3% of people, a high level of ethyl glucuronide was found in the blood, which indicates alcohol consumption 96 hours before death. Heart lesions were represented by dilated cardiomyopathy and myocardial fibrosis.

Conclusion. Histological features of ACMP include parenchymal remodeling with dystrophic changes, uneven hypertrophy of cardiomyocytes against the background of stromal, perivascular, and subendocardial fibrosis; intimal “cushion-like” protrusions and sclerosis of intramural arteries; microcirculatory disorders with sludge phenomenon; and focal-diffuse lipomatosis of the wall of the left and right ventricles to the subendocardial sections. Myocardial fibrosis was focal or diffuse, developed mainly in the interstitial spaces around blood vessels, and was accompanied by the proliferation of connective tissue cells of fibroblasts, simultaneously with a decrease in the number of myocytes.

Key words: sudden cardiac death**,** chronic alcohol consumption, cardiac changes, ethyl glucuronide, alcoholic cardiomyopathy.

Introduction. Sudden death from cardiovascular diseases (CVD) is most prevalent in

industrialized and urbanized nations, representing one of the significant health challenges. In forensic practice, when examining corpses of individuals aged 20 to 60 years who died unexpectedly, diagnostic difficulties often arise due to the absence of significant pathological changes in the cardiovascular system. One such group of concern consists of individuals who have consumed alcohol over an extended period. However, the minimal concentration of ethanol in the blood or urine of the deceased, or its absence, hampers the diagnosis of death due to ethyl alcohol poisoning.

Alcohol is among the most widely consumed toxic substances globally [1]. Research indicates that low to moderate daily alcohol consumption can enhance cardiovascular health in patients [2, 3], while chronic and excessive consumption may lead to progressive heart failure [4]. Chronic alcohol consumption, or abuse, is defined as daily intake exceeding 80 to 90 grams of alcohol (approximately eight drinks) for a minimum of five years [5-8]. Women develop alcoholic cardiomyopathy (ACMP) at lower levels of alcohol intake compared to men, yet the differences in the amount of alcohol necessary to develop the disease remain unclear [9]. This level of alcohol exposure results in diminished cardiomyocyte contractility, ventricular dilation, and fibrosis, representing the morphological basis of dilated cardiomyopathy [7]. ACMP is clinically characterized as a form of dilated cardiomyopathy that arises from chronic alcohol abuse and is recognized by the World Health Organization as a distinct clinical entity, complete with its own International Classification of Diseases (ICD-10) code (I 42. 6). Clinically and histologically, ACMP cannot be distinguished from idiopathic dilated cardiomyopathy, making the patient history crucial for diagnosis [10]. Given the absence of specific pathological changes, forensic identification of ACMP must rely on the patient's medical history and the exclusion of other causes of cardiomyopathy. ACMP accounts for approximately 3.8% of all reported cases of cardiomyopathy and 21 to 36% of all reported instances of non-ischemic dilated cardiomyopathy [6].

This article reviews the forensic identification of ACMP, aiming to provide reference materials for forensic pathologists and clinicians.

The aim of the study is to determine the characteristics of the age-sex distribution and pathomorphological changes of the heart and vessels in forensic cases of ACMP.

Material and methods. Seventy cases of ACMP were analyzed based on data from the State Specialized Institution "Kyiv City Bureau of Forensic Medical Examination" over three years (2019, 2021 and 2023). Statistical information regarding the number of fatal cases of ACMP in Ukraine over eight years was processed following the State Statistics Service of Ukraine (https://stat.gov.ua/uk/topics/okhorona-zdorovya).

The forensic diagnosis of ACMP was determined for deceased individuals who were chronic alcohol consumers, in conjunction with pathomorphological changes in the heart and blood vessels, as well as the determination of ethanol levels in blood and urine.

Macroscopically, the following heart lesions were identified during autopsy: left ventricular hypertrophy, dilated cardiomyopathy, and endocardial and myocardial fibrosis.

Tissues from various parts of the heart (anterior and posterior walls, interventricular septum) and coronary arteries were examined histologically. Standard staining methods for paraffin sections, including hematoxylin and eosin, and specific techniques such as Hart's resorcinol fuchsin staining and Masson's trichrome, were employed.

Blood and urine samples from the deceased were collected within a maximum of four hours post-mortem to determine ethanol levels using gas chromatography.

The data were centralized in the Statistical Package for the Social Sciences (SPSS) 18.0 database and processed with appropriate statistical functions. The significant threshold was set at 95%.

Bioethics. The study was conducted in accordance with the ethical principles set forth in the Declaration of Helsinki (1964) and subsequent amendments thereto. Ethical approval was obtained from the Committee on Ethics of Scientific Research, Experimental Developments and Scientific Works of the Danylo Halytskyi Lviv National Medical University (excerpt from protocol No. 14

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Results and discussion. According to the State Specialized Institution "Kyiv City Bureau of Forensic Medical Examination", 16,530 autopsies were performed in 2019, 2021, and 2023. The share of deaths from cardiovascular diseases among all forensic medical examinations was 6.9% (1,143 autopsies). ACP was diagnosed in 70 cases, 0.42% of the total number of autopsies for these years. The annual number of forensic medical examinations did not change significantly ($p>0.05$) and averaged 5,510±34 autopsies yearly. In addition, when comparing these years, no significant difference was observed in the shares of CVD and ACMP ($p>0.05$). Thus, the average number of autopsies for cardiovascular diseases was 381±31 per year, while ACMP cases averaged 23±45. It is important to note that these years were chosen deliberately; 2019 was a relatively calm year, 2021 was the peak of coronavirus infections, and 2023 was the second year of the russian-Ukrainian war. Despite these significant influencing factors, the number of deaths and the structure of mortality during these periods did not change (Fig. 1).

We observed similar trends when comparing our results with data from the State Statistics Service of Ukraine [11] for eight years (2015-2022). According to the State Statistics Service, presented in the table, ACMP consistently occupies a stable share in the mortality structure in Ukraine, on average 0.6% of all deaths, and tends to increase (from 0.57% in 2015 to 0.66% in 2022), despite the decrease in the total number of deaths (by 22,388 cases from 2015 to 2022), in particular, due to diseases of the circulatory system (by 37,311 cases from 2015 to 2022).

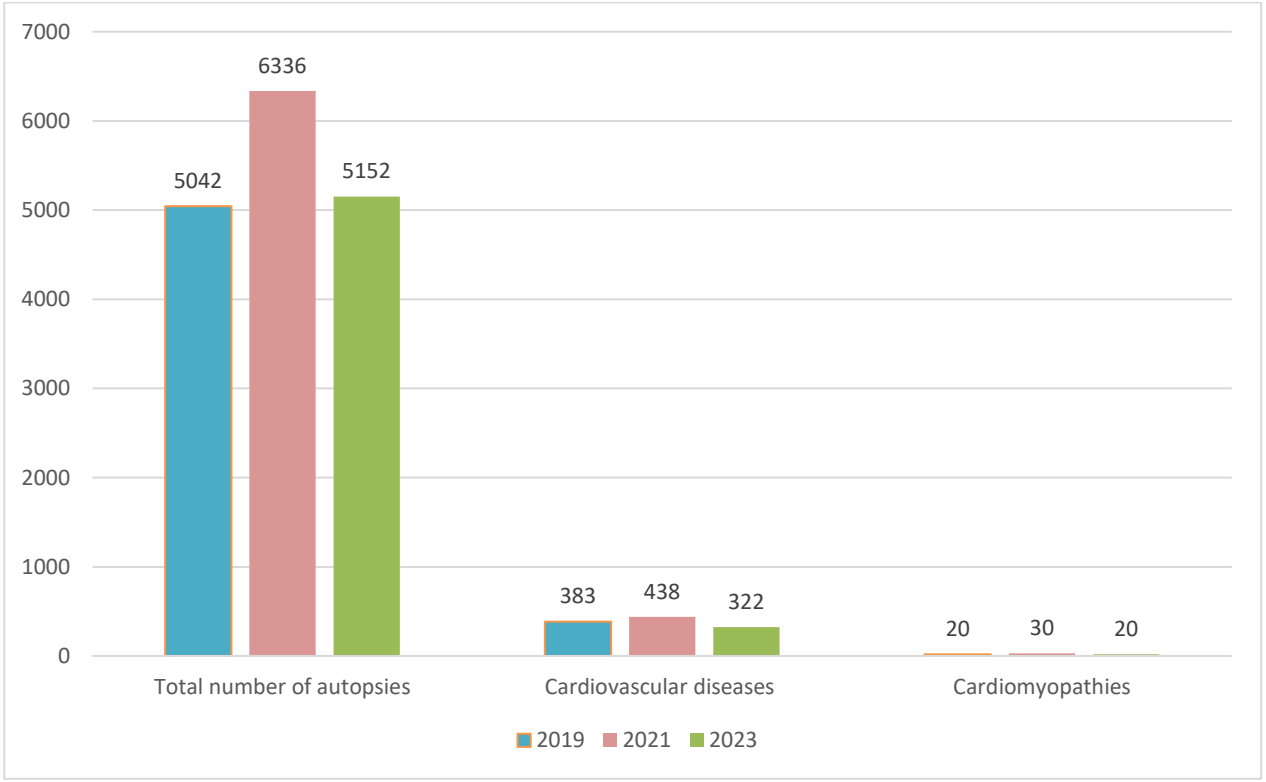

Fig. 1. Total number of autopsies, cardiovascular diseases, and cardiomyopathies for 2019, 2021, and 2023.

Table

Statistical information on the number of deaths from alcoholic cardiomyopathy (ACMP) among all deaths and cardiovascular diseases (CVD) in Ukraine for 2015-2022*

Year	Total		CVD		ACMP	
	abs. number	%	abs. number	%	abs. number	%
2022[8]	572408	100	367240	64,0	3379	0,66
2021[7]	714263	100	430013	60,2	3526	0,49
2020[6]	616835	100	408721	66,26	3597	0,58
2019[5]	581114	100	389348	67,0	3718	0,64
2018[4]	587665	100	392060	66,71	3933	0,67
2017[3]	574123	100	384810	67,03	3423	0,60
2016[2]	583631	100	392298	67,22	3218	0,55
2015[1]	594796	100	404551	68,02	3414	0,57

*Note:
[1]https://index.minfin.com.ua/ua/reference/people/deaths/2015/
[2]https://index.minfin.com.ua/ua/reference/people/deaths/2016/
[3]https://index.minfin.com.ua/ua/reference/people/deaths/2017/
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[8]https://index.minfin.com.ua/ua/reference/people/deaths/2022/

The studied group with ACMP included 70 deceased individuals aged 16 to 40. We divided the age groups into decades (up to 20 years, 21-30, and 31-40 years). Among the deceased, 9 (12.85%) were under 20 years old, 12 (17.15%) were in the 21-30 age group, and 49 (70%) were aged 31-40 years. Regarding gender distribution, men outnumbered women by almost three to one. Of the deceased, 51 (72.8%) were men, and 19 (27.2%) were women.

Among the accompanying pathologies, chronic alcoholic hepatitis and hepatosis, as well as left-sided lower lobe bronchopneumonia, were found in one-third of cases. In 8 (11.4%) instances, pulmonary embolism was identified, linked to the presence of parietal thrombi.

The ultimate cause of death for the deceased was acute cardiac and cardiorespiratory failure, resulting from cardiac damage.

According to toxicological research results, 45 (64.3%) of the deceased had a blood alcohol concentration (in the resorption phase) of no more than two ppm and in urine (in the elimination phase) of no more than 2-3 ppm. The remaining 35.7% showed no ethanol in the biological fluids analyzed.

Compared with other known enzyme markers, the analysis for ethanol demonstrates greater sensitivity and specificity. Measurement of the amount of ethanol in blood samples taken during forensic medical examination is the main evidence of chronic alcohol abuse. Detection of ethanol in the blood, in parallel with the study data and post-mortem diagnostics, can help in the diagnosis of chronic ethanol intoxication and clarify controversial situations [12].

Gross examination revealed significant dilation of the heart chambers in all of the deceased, typically in a spherical shape. The myocardium mass ranged from 375 to 1100 g (average 685.6±163.7 g). In 59 (84.2%) of the deceased, thickening of the left ventricular wall, measuring between 1.2 to 2.0 cm (average 1.6±0.4 cm), was observed, which is atypical for idiopathic dilated cardiomyopathy; among these, 10 (14.2%) exhibited hypertrophy in both ventricular walls, while 34 (48.5%) had hypertrophy solely in the left ventricle. In the coronary arteries of deceased individuals aged 31-40 years, solitary atherosclerotic plaques in the liposclerosis stage, with a lesion area of 15-20% and without signs of stenosis, were noted. There were visual indications of flaccidity and

dullness of the myocardium upon dissection, a color change to red-brown, and uneven hypertrophy of the ventricular walls. Other observations included venous congestion, enlargement of the liver and kidneys, fibrosis of the meningeal membranes, and pulmonary edema.

During microscopic examination of the myocardium, engorgement of small arteries and veins with leukocyte stasis and erythrocyte sludge phenomena was detected in all cases (Fig. 2).

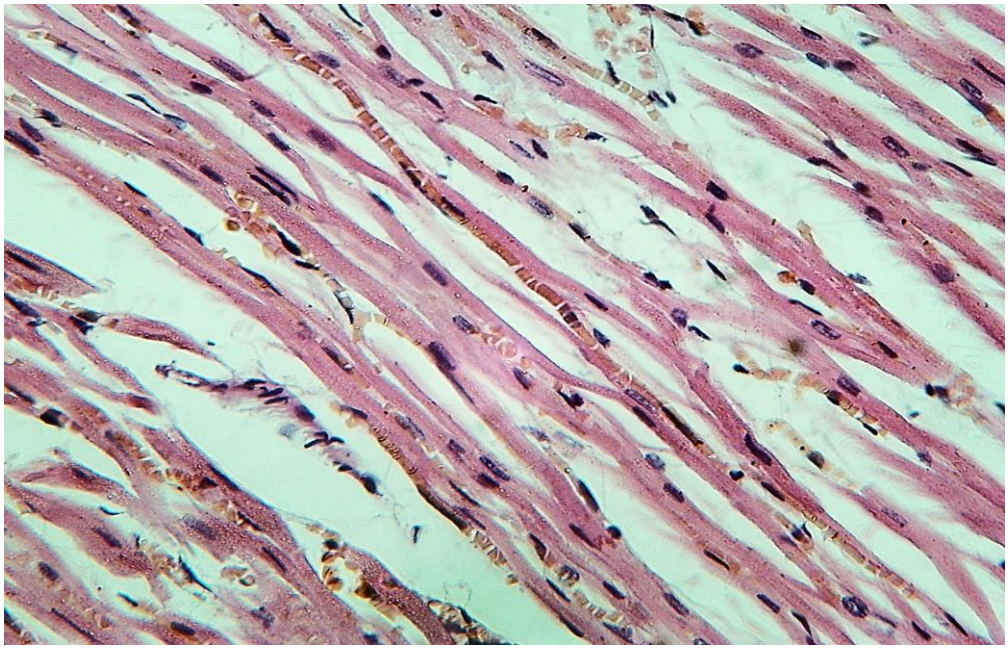

Fig. 2. Hyperemia and erythrocyte sludge in the myocardial microcirculation in alcoholic cardiomyopathy. Hematoxylin-eosin x 250.

In 19 (27.2%) cases, “cushion-like” intimal protrusions into the vascular lumen occurred due to endothelial cell proliferation (Fig. 3). Moderate myocardial edema was noted in 24 (34.2%) cases Stromal myocardial fibrosis from focal to diffuse was detected in almost all (88.5%) cases (Fig. 4, 5).

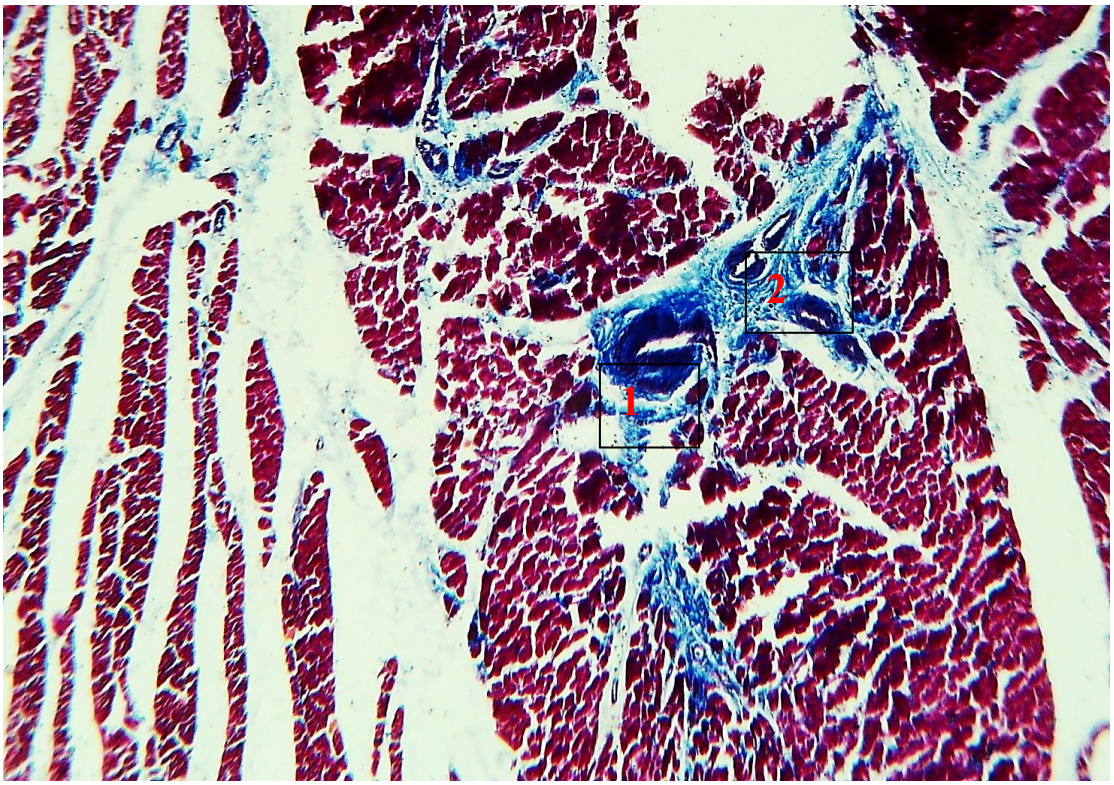

Fig. 3. Sclerotic changes in intramural vessels with segmental hypertrophy (1) and

perivascular sclerosis (2). Masson's trichrome x 60.

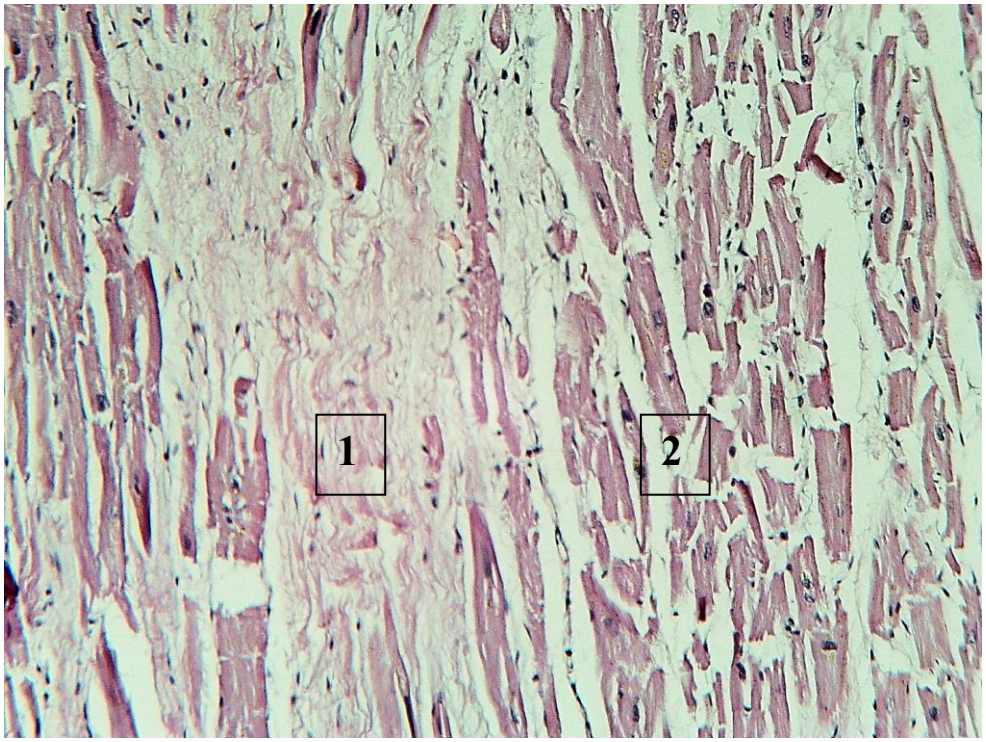

Fig. 4. Focal stromal myocardial fibrosis (1), multiple fragmentations of cardiomyocytes (2). Hematoxylin-eosin x100.

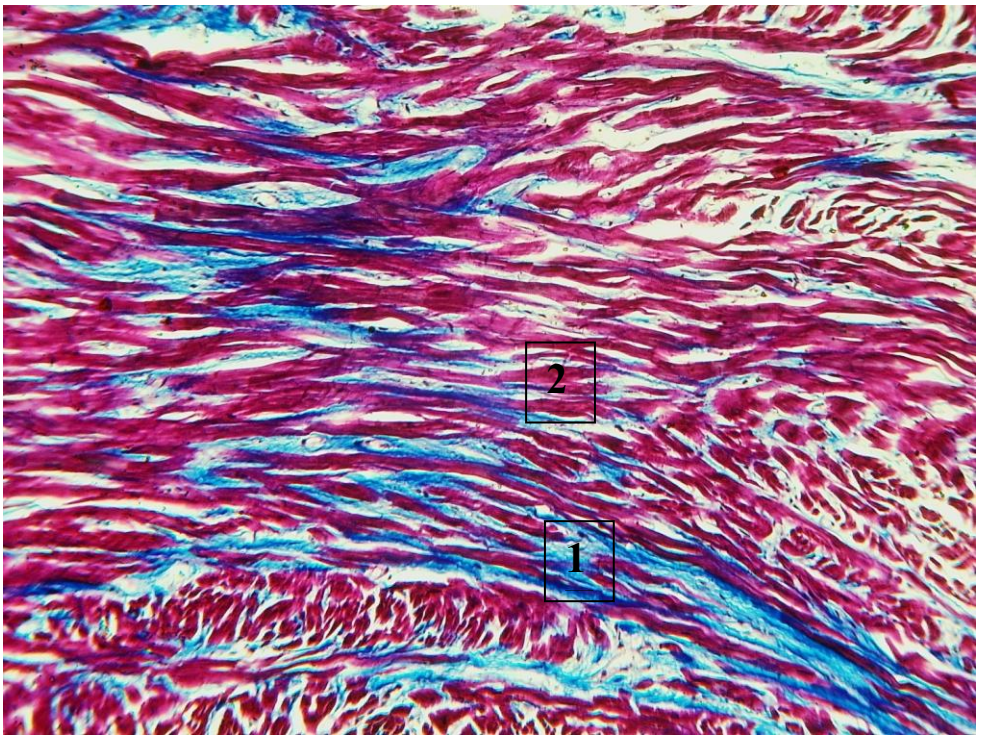

Fig. 5. Diffuse stromal fibrosis: proliferation of fibrous connective tissue (1) between unevenly hypertrophied cardiomyocytes (2). Staining with Masson's trichrome x100.

In 15 cases (21.4%), sclerotic thickening of specific areas of the endocardium and isolated small mural thrombi were observed.

In one-third of the cases, slight focal lymphocytic infiltration within the stroma (5 to 10 lymphocytes in the field of view) was noted, accompanied by minor amounts of segmented leukocytes.

In 25 cases (35.7%), infiltrative proliferation of fatty tissue was observed between muscle fibers in both the left and right ventricles, occasionally extending into the subendocardial zones.

In all cases, the prominent morphological features included uneven hypertrophy of cardiomyocytes with large, irregularly shaped nuclei, wave-like deformation of cardiomyocyte dystrophy, and significant fragmentation of cardiomyocytes with focal myocytolysis (Fig. 6).

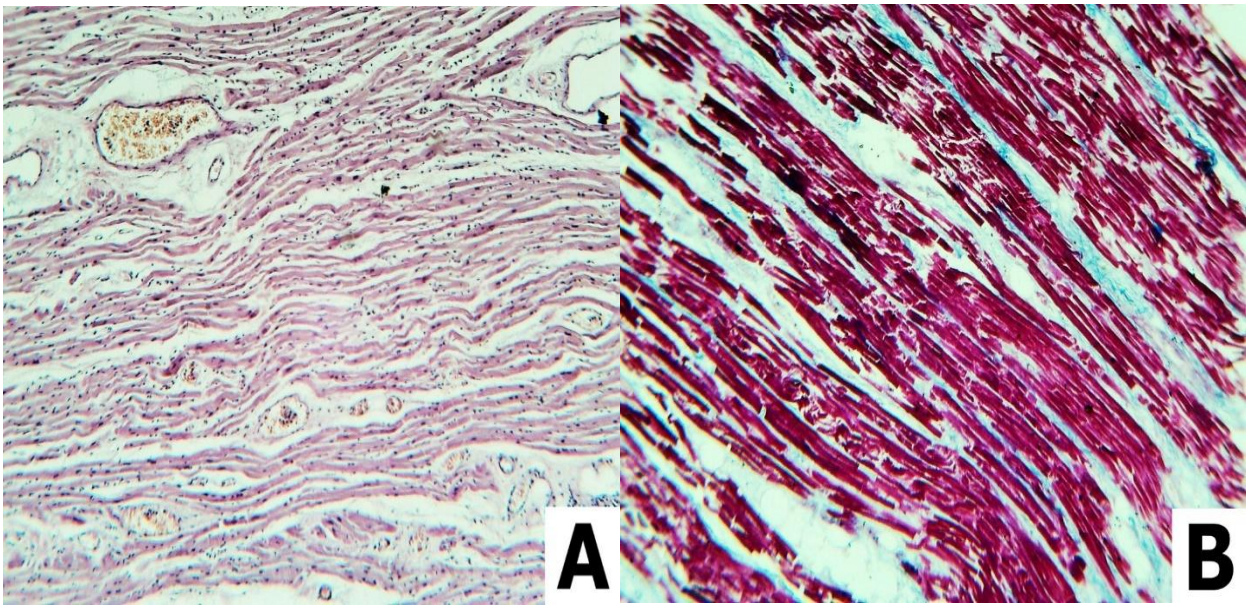

Fig. 6. Dystrophic changes in cardiomyocytes in alcoholic cardiomyopathy:
A – wave-like deformation of fibers against the background of significant edema of the stroma and interstitium. Hematoxylin-eosin x100; B – fragmentation of fibers against the background of moderate edema of the interstitium and myocardial fibrosis. Trichrome Masson x100.

In more than half of the cases, hypertrophy of cardiomyocytes, dullness, and granularity of the cytoplasm with lipofuscin accumulation were determined (Fig. 7).

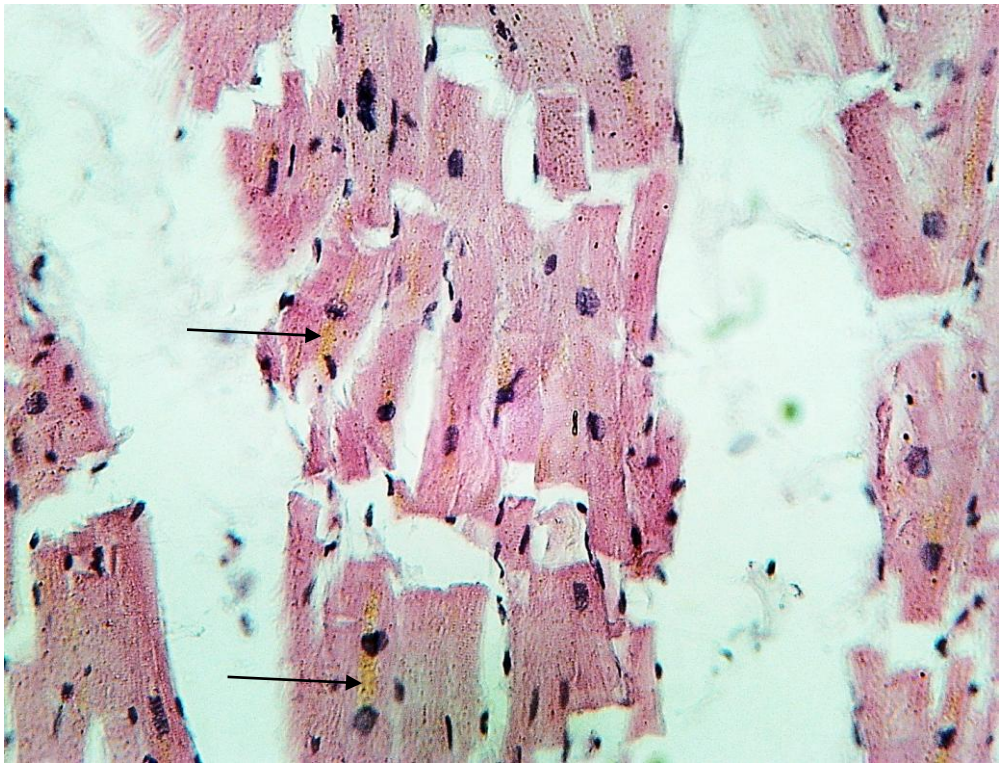

Fig. 7. Hypertrophy and fragmentation of cardiomyocytes and accumulation of lipofuscin

grains (arrow) in the cytoplasm. Hematoxylin-eosin x400.

In 20% of all studied cases, a few small focal hemorrhages in the interstitium were determined.

Modern forensic literature data indicate that the development of microangiopathy and multiorgan pathology with mandatory damage to the liver, heart, and brain accompanies alcohol abuse. The degree of structural and functional disorders of organs and systems is different and is determined by the type of alcohol intoxication. It is for chronic alcohol intoxication, without the formation of alcohol dependence (drunkenness), that the gradual development of ACMP is characteristic. Andersson K. et al. (2022) believe that ACMP is partially reversible if alcohol consumption is stopped and in the absence of severe myocardial damage [13].

Our study confirms the observations of other authors who claim that chronic alcohol abuse reduces structural protein synthesis with sarcomere disorganization, which is histologically manifested by focal dissolution or vacuolization of cells and lysis of cardiomyocytes [14-16]. It has been proven that changes in the extracellular matrix are present in almost all cases of cardiomyopathies caused by excessive alcohol consumption [17-19] after myocytes' apoptosis or necrosis. In this case, myocardial regeneration is ineffective, and the fibrosis process is significant, which leads to left ventricular dysfunction and heart failure [20, 21].

Conclusions.

1. A forensic medical examination of 70 cases demonstrated that chronic alcoholism can develop in adolescence. The deceased were predominantly men aged over 30 years.

2. Characteristic macroscopic changes include cardiomegaly with enlarged heart cavities and left ventricular hypertrophy, resulting in a spherical heart shape.

3. Moderate atherosclerotic changes with no signs of stenosis were observed in the coronary arteries of deceased individuals aged 31-40 years.

4. Elevated blood and urine ethanol levels were found in 64.3% of the study group, suggesting alcohol consumption within 96 hours before death.

5. Histological characteristics of ACMP encompass parenchymal remodeling with dystrophic alterations, uneven hypertrophy of cardiomyocytes amid stromal, perivascular, and subendocardial fibrosis; intimal “cushion-like” protrusions and sclerosis of intramural arteries; microcirculatory disturbances associated with sludge phenomenon; and focal-diffuse lipomatosis in the walls of the left and right ventricles, particularly in subendocardial areas. Myocardial fibrosis varied from focal to diffuse, primarily occurring in interstitial spaces around blood vessels, accompanied by fibroblast proliferation and decreased myocyte numbers.

6. The leading causes of death in ACMP include the progression of heart failure, the emergence of arrhythmias or cardioembolic complications, and secondary bacterial infections like bronchopneumonia.

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СУДОВО-МЕДИЧНА ІДЕНТИФІКАЦІЯ РАПТОВОЇ СЕРЦЕВОЇ СМЕРТІ ПРИ АЛКОГОЛЬНІЙ КАРДІОМІОПАТІЇ

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Резюме. Алкоголь – найвідоміша отруйна речовина, негативний вплив якої на здоров'я та спосіб життя людини доведено. Хронічний алкоголізм – це патологічний стан, який виникає після надмірного вживання алкоголю і може спостерігатися у чоловіків молодого та середнього віку.

Мета роботи – визначити особливості віково-статевого розподілу та патоморфологічних змін серця і судин у судово-медичних випадках алкогольної кардіоміопатії (АКМП).

Матеріал і методи. Нами було досліджено зміни міокарда лівого шлуночку внаслідок вживання алкоголю. Були досліджені у 70 тіл померлих вдома осіб, які були направлені до ДУ «Київське міське бюро судово-медичної експертизи» для встановлення причини смерті.

Біоетика. Дослідження було проведено відповідно до етичних принципів, викладених у Гельсінській декларації (1964) та наступних поправок до неї. Етичне схвалення було отримано від Комітету з етики наукових досліджень, експериментальних розробок та наукових робіт Львівського національного медичного університету імені Данила Галицького (витяг із Протоколу № 14 від 20 грудня 2023 року). Усі дані були анонімні та оброблені в умовах суворої конфіденційності для збереження приватних даних померлих та їхніх сімей.

Науково-дослідна робота. «Вивчення патогенетичних механізмів та патоморфологічних особливостей захворювань ендокринної, серцево-судинної, дихальної, нервової, травної, сечовидільної та репродуктивної систем і перинатального періоду з метою вдосконалення їх морфологічної діагностики». Шифр теми: IN.07.00.0001.18. Номер державної реєстрації: 0122U201668

Результати. Досліджувану групу з АКМП склали 70 померлих віком від 16 до 40 років, з них 49 (70%) віком від 31 до 40 років, з них 51 (72,8%) чоловіки та 19 (27,2%) жінки. Серед супутньої патології у третини випадків виявлено хронічний алкогольний гепатит і гепатоз, лівосторонню нижньочасткову бронхопневмонію. У 8 (11,4%) випадках виявлена ТЕЛА, пов'язана з наявністю пристінкових тромбів. Остаточна причина смерті померлих – гостра серцева та дихальна недостатність, яка виникла внаслідок ураження серця. У 64,3% осіб виявлено високий рівень етилглюкуроніду, що свідчить про вживання алкоголю за 96 годин до смерті. Ураження серця були представлені дилатаційною кардіоміопатією та фіброзом міокарду.

Висновки. Гістологічні особливості АКМП включають ремоделювання паренхіми з дистрофічними змінами, нерівномірну гіпертрофію кардіоміоцитів на тлі стромального, періваскулярного та субендокардіального фіброзу; «подушкоподібні» випинання інтими та склероз інтрамуральних артерій; порушення мікроциркуляції зі сладж-феноменом та вогнищево-дифузний ліпоматоз стінки лівого та правого шлуночків до субендокардіальних відділів. Фіброз міокарда був вогнищевим або дифузним, розвивався, переважно, в інтерстиціальних просторах навколо кровоносних судин і супроводжувався проліферацією

сполучних клітин фібробластів, одночасно зі зменшенням кількості міоцитів.

Ключові слова: раптова серцева смерть, хронічне вживання алкоголю, серцеві зміни, етилглюкуронід, алкогольна кардіоміопатія.

Conflict of interest

The authors declare that they have no conflict of interest.

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