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ISOLATED NON-COMPACTION OF THE LEFT VENTRICULAR MYOCARDIUM: A CLINICAL AND MORPHOLOGICAL STUDY

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Isolated left ventricular noncompaction (LVNC) in adult patients is a rare form of primary cardiomyopathy. There have been several morphological studies of this condition in which a heart transplantation was performed. **Objective:** to analyze literature and clinical cases of patients with LVNC, macroscopic and histological data of the removed hearts. **Materials and methods.** At our center three patients (2 women aged 18 and 31, and 1 man aged 49) were morphologically diagnosed with LVNC had a heart transplant. We retrospectively analyzed the clinical, macroscopic and histological data of the removed hearts in these patients and the results of the transplants performed. Light microscopy of a fixed myocardial preparation stained with hematoxylin and eosin was used for histological examination. **Results.** A histological examination confirmed the presence of LVMI in these patients. **Conclusion.** LVMI is a rare disease, that can occur asymptomatic or cause severe congestive heart failure, requiring transplantation.

Keywords: isolated left ventricular noncompaction, heart transplantation.

Isolated left ventricular noncompaction (LVNC) is a rare non-compaction cardiomyopathy. More often than not, left ventricular noncompaction (LVNC) is combined with other heart defects. There are known observations of biventricular noncompaction. All forms of non-compact myocardium are rare observations, characterized by abnormal myocardial embryogenesis, resulting in preservation of inter-trabecular sinusoids and development of spongy myocardium [1]. Normally, the process of ventricular myocardial compaction, which occurs within 5–8 weeks of fetal development, begins from the epicardium, spreading to the endocardium and from the basal sections to the apex of the heart [2]. With isolated LVNC, the left ventricular wall, especially in the apex region, becomes thicker. However, this occurs due to increased thickness of the spongy layer, while the compact layer, on the contrary, remains thin [3]. Isolated LVNC is diagnosed via echocardiography and/or magnetic resonance imaging, contrast ventriculography is rarely used [4]. Endomyocardial biopsy in isolated LVNC [5], in our opinion, is uninformative and inappropriate, because fragments of the subendocardial zone fall into the biopsy.

Differential diagnosis of isolated LVNC should be performed with idiopathic dilated cardiomyopathy [6–8] and with corrected transposition of the great vessels, where the right ventricle (RV) is located in the position of the left ventricle (LV), which can be mistaken for a non-compact myocardium. Clinical symptoms depend on the volume and location of a non-compact myocardium. Often the disease is manifested by ventricular arrhythmia, which requires implantation of a cardioverter defibrillator. These patients are often mistakenly diagnosed with idiopathic dilated cardiomyopathy [9].

In symptomatic patients with isolated LVNC, a developing heart failure is predominantly associated with systolic and diastolic dysfunction of the LV. Systolic dysfunction arises from significant reduction in the compact layer, and not as a result of relative myocardial ischemia due to a mismatch between myocardial need and the amount of oxygen delivered, as suggested by Y. Agmon et al. [3]. Diastolic dysfunction mechanism includes a combination of pathological relaxation and deficiency of blood supply to the LV as a result of hypertrabeculation [3]. Heart failure in isolated LVNC can occur at any age, from infants to the elderly.

According to M. Greutmann et al. [10], of the total of 115 patients, 77% had symptoms of the disease. Compared to the asymptomatic patients, the symptomatic patients were significantly older and had larger left ventricular cavities and worse left ventricular ejection fraction (EF). During a median follow-up of 2.7 years (range 0.1 to 19.4), none of the asymptomatic patients died or underwent heart transplantation, compared to 31% (27 of 88) of the symptomatic patients ($p = 0.001$). In patients with NYHA class III or above, cardiovascular complications are the main predictors of adverse outcomes. Left ventricular dilatation and systolic dysfunction are less significant predictors [10].

LVNC is more often combined with congenital heart defects [11], but there is also an isolated form, which can equally cause severe heart failure [12]. These patients have unfavorable outcomes due to accelerated develop-

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ment of fatal complications – arrhythmias, thromboembolism and severe left ventricular decompensation of blood circulation [13]. Therefore, heart transplantation is the only and radical treatment option for isolated LVNC patients who develop severe congestive heart failure.

T. Spieker et al. [14] presents the results of echocardiography and pathomorphological examination of the hearts of two newborn boys with isolated LVNC, who underwent heart transplantation at 40 days of age. According to the authors, it is very difficult diagnosing isolated LVNC in newborns because compared to adult patients, pathological changes in the myocardium are much less pronounced.

W.A. Zuckerman et al. [15] performed a retrospective analysis of mortality and heart transplant outcomes in pediatric patients with isolated LVNC who were treated at Morgan Stanley Children's Hospital in New York from January 1993 to September 2009. LVNC was diagnosed in 50 patients, 34 of them were less than 1 year of age. Twenty-six patients died or underwent a heart transplant. Patients surviving 1 year after presentation had 75% conditional survival, and patients surviving 2 years after presentation had 92% conditional survival. Independent predictors of poor outcome were hemodynamic instability, decreased ventricular function, and left ventricular dilatation. Of the 21 patients who presented with hemodynamic instability, 17 died or underwent transplantation at a median of 0.08 years after diagnosis with isolated LVNC. The authors conclude that heart transplantation is necessary for children with isolated LVNC as early as possible after diagnosis of the disease.

Until 2001, only six patients with isolated LVNC underwent heart transplantation [4]. These authors describe diagnostic difficulties in examining a young woman with neurological symptoms, atrial fibrillation, and severe systolic dysfunction, which ultimately led to heart transplant. This was the seventh surgery in a similar group of patients.

S. Stamou et al. [5] cited the eighth observation in which a successful heart transplant was performed on a patient with isolated LVNC. An 18-year-old male patient, who had not previously been ill, was admitted at the Inova Fairfax Hospital for examination due to weakness, cough, and abdominal pain. Chest roentgenogram revealed cardiomegaly and pulmonary venous congestion. An echocardiogram demonstrated dilated cardiomyopathy with an ejection fraction less than 10%, mild mitral regurgitation and moderate tricuspid insufficiency, despite intravenous dobutamine treatment. The patient's condition progressively deteriorated. Repeat echocardiogram, unlike the first, revealed excessive trabeculations with deep recesses in the apex and in the middle third of the LV. For more than five months, the patient remained in the hospital on continuous intravenous inotropic support, and then he successfully underwent a heart transplant. The explanted heart weighed 426 g. Pathoanatomical examination confirmed isolated LVNC diagnosis. After heart transplantation, the patient was completely rehabilitated; he studied and worked for the next 2.5 years after surgery.

The ninth observation of heart transplantation in a non-compact myocardium was presented by J. Bordes et al. [16]. In this observation, noncompaction of the ventricular myocardium was associated with bicuspid aortic valve in a 42-year-old man who suffered from refractory acute heart failure and was successfully treated by heart transplantation. Prior to heart transplantation, transesophageal echocardiography revealed bicuspid aortic valve insufficiency, left ventricular dilatation with 40% ejection fraction. A surgical valve repair was proposed though the patient refused surgery. After 3 months, the patient was admitted to hospital with congestive heart failure in the intensive care unit. On admission (on dobutamine 20 mg/kg per minute), the heart rate was 89 beats per minute and blood pressure was 80/50 mmHg. Echocardiography showed severely depressed left ventricular systolic function with 25% ejection fraction. The LV was dilated with severe functional mitral regurgitation. Aortic regurgitation was measured minimal. Repeat echocardiography visualized multiple ventricular trabeculations in the LV, predominant to apical and mid-inferior areas. The maximal end systolic ratio of noncompacted to compacted layers was greater than 2. The RV appeared to be more heavily trabeculated than normal. Final clinical diagnosis: biventricular noncompaction. Subsequently, the patient underwent a heart transplantation three days after admission. Postoperative extracorporeal circulatory support was necessary for 24 hours. The patient was extubated on postoperative day 6. He was discharged from the intensive care unit on day 17 of post-transplantation and his condition remained satisfactory for the subsequent 2 months [16].

A 22-year-old Hispanic male presented with a two-month history of chest discomfort. Transthoracic echocardiogram revealed prominent trabeculae and spongiform appearance of the LV with 15–20% ejection-fraction, as well as similar changes in the right ventricular myocardium. Magnetic resonance imaging confirmed the echocardiogram data: excessive trabeculation of the left-ventricular apex and mid-ventricular segments, as well as at the apical and lateral wall of the RV. Cardiac catheterization showed an intact cardiac vessel system. The patient was placed on the heart transplant waitlist [17]. So, the young patient required a heart transplant due to severe heart failure resulting from biventricular noncompaction.

In some LVNC patients, a prolonged asymptomatic course is observed, while in others, progression of left ventricular systolic dysfunction is noted, resulting in death of patients if they have not undergone heart transplantation [4, 18]. In refractory heart failure developing in 4–12% of patients with noncompaction cardiomyo-

pathy, emergency heart transplantation is required [4]. However, this operation is largely limited due to shortage of donor organs [19].

MATERIALS AND METHODS

The case histories of three patients who presented with isolated LVNC were analyzed and the morphology of their ventricles that were removed during transplantation was studied in detail. Macroscopic and histological examination of the left ventricular anterior and lower walls, as well as the right ventricular free wall and interventricular septum were carried out.

After fixation with neutral formalin and dehydration, the material was poured into paraffin. Histological sections were stained with hematoxylin and eosin, and Masson's trichrome. PAS reaction was carried out and enclosed in Canadian balsam. Histological preparations were examined using a light microscope.

OWN CASES

Case No. 1

18-year-old female patient A.T.A. was admitted at Shumakov National Medical Research Center of Transplantology and Artificial Organs on November 10, 2009 presenting with shortness of breath with little physical activity and fatigue. ***Admission diagnosis:*** *Isolated LVNC syndrome, NYHA class 3, group 2 pulmonary hypertension, paroxysmal atrial fibrillation, paroxysmal supraventricular and ventricular tachycardia, incomplete left bundle branch block, UNOS status 1B.*

Anamnesis morbi. *She has been sick since the age of five. Until the age of 18, she was on the record of the Institute of Pediatrics, the USSR Academy of Medical Sciences. Appearance of paroxysmal supraventricular tachycardia has been noted since 1998. In 2007, there was an episode of acute left ventricular failure, arrested by diuretics and hormone therapy. In 2008, the patient was diagnosed with dilated cardiomyopathy, and in August 2009 she was diagnosed with isolated LVNC syndrome, NYHA class 3, and severe pulmonary hypertension. Therapy: dilantrend, prestarium, veroshpiron, furasemide, rhythmorm.*

Examination upon admission: *The patient's condition at admission was stable, moderately severe. Height 166 cm, body weight 43 kg. Pale skin. No peripheral edema. Lip cyanosis, acrocyanosis. No shortness of breath at rest. Vesicular breathing over the lungs, no wheezing. The heart borders are extended to the left by 1.5 cm from the mid-clavicular line. Arrhythmic heart sounds, systolic murmur at the apex and at the fifth point, extrasystole, heart rate of 90 beats per minute, and 85/50 mmHg blood pressure. Soft, painless abdomen. Liver and spleen are not enlarged. No focal neurological symptoms.*

Echocardiogram: left ventricular end-diastolic diameter (LVEDD) – 6.2 cm, left ventricular end systolic volume (LVESV) – 196, EF – 39–40%, pulmonary artery pressure (PAP) – 60 mmHg. Spherical heart with diffuse hypokinesis. A picture of left ventricular noncompaction with visualization of a narrow strip of up to 3 mm of compact myocardium.

Assessment of central hemodynamics: with no nitric oxide – heart rate – 91 bpm, blood pressure – 96/75/69 mmHg, pulmonary capillary wedge pressure (PCWP) – 33 mmHg, PAP – 72/53/38 mmHg, total pulmonary resistance (TPR) – 6.45 Wood units; use of functional samples of inhaled nitric oxide, heart rate – 96 bpm, blood pressure – 91/73/67 mmHg, PCWP – 18 mmHg, PAP – 36/28/20 mm Hg, TPR – 3.33 Wood units, which proved that pulmonary hypertension is reversible and that there are no contraindications for heart transplantation. Orthotopic heart transplantation was performed on November 26, 2009. Induction immunosuppression – Simulect 20 mg. The postoperative period was uneventful.

Pathoanatomical examination of native heart. Macroscopic examination results: *Heart ventricles are spherical in shape, isometric, excised along the atrioventricular groove, weighing 195 g, measuring 11.5 × 8 × 3.5 cm. Coronary arteries are wide, without stenosis. Fibrous ring of the mitral valve is 12 cm in perimeter. The left ventricular free wall is 0.8 cm thick, of which the compact layer is 2–3 mm thick. Severe left ventricular subendocardial fibrosis. Incised LV myocardium is brown, flabby, chord germination into the myocardium of the anterior left ventricular wall and part of the interventricular septum. The fibrous ring of the tricuspid valve is 13 cm in perimeter. Right ventricular free wall is 0.3 cm thick. Leaflets of the tricuspid valve are whitish in color.* ***Microscopic examination:*** *In the anterior left ventricular wall, in a thinned compact layer, severe diffuse albuminous degeneration and focal hydropic degeneration of cardiomyocytes. Individual cells are necrotic. In PAS reaction, uneven staining of the cytoplasm of cardiomyocytes (Fig. 1). Large thin-walled blood vessels are found in the anterior wall, and especially in the lower wall in the compact layer (Fig. 2). In the myocardial spongy layer, severe trabeculae endocardial sclerosis (Fig. 3). In the interventricular septum, excessive formation of fatty tissue and nerve trunks with perineural proliferation of connective tissue was noted (Fig. 4).* ***Pathoanatomical diagnosis:*** *Isolated left ventricular noncompaction with secondary LV dilation.*

Thus, heart failure was caused by isolated left ventricular noncompaction with secondary dilated left ventricle. Orthotopic heart transplantation was successfully performed on November 26, 2009. The patient was discharged from the clinic on December 29, 2009 in a satisfactory condition.

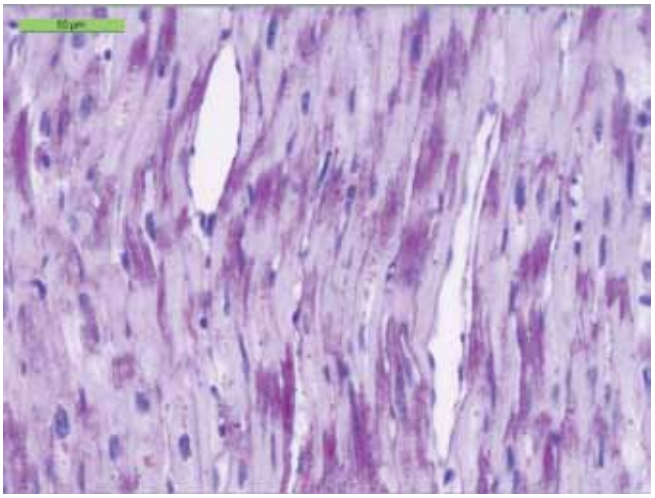

Fig. 1. Non-uniform PAS-positive colouring of the cytoplasm of the cardiac myocytes in a anterior wall of the left ventricle. PAS stain. ×400

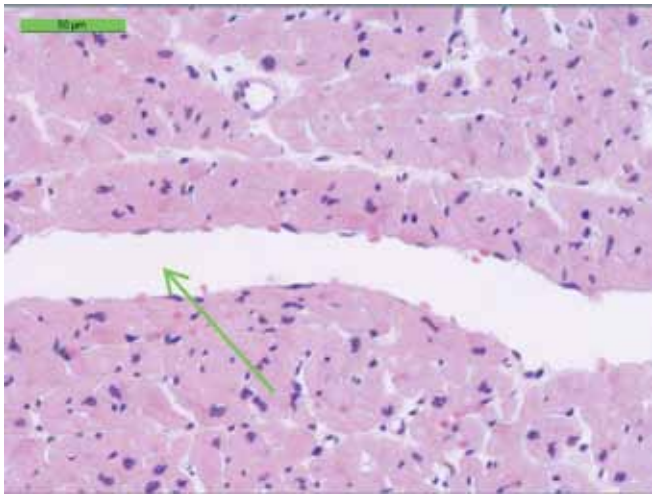

Fig. 2. Large thin-walled blood vessel (green arrow) in a compact layer of the inferior wall of the left ventricle. H & E stain. ×400

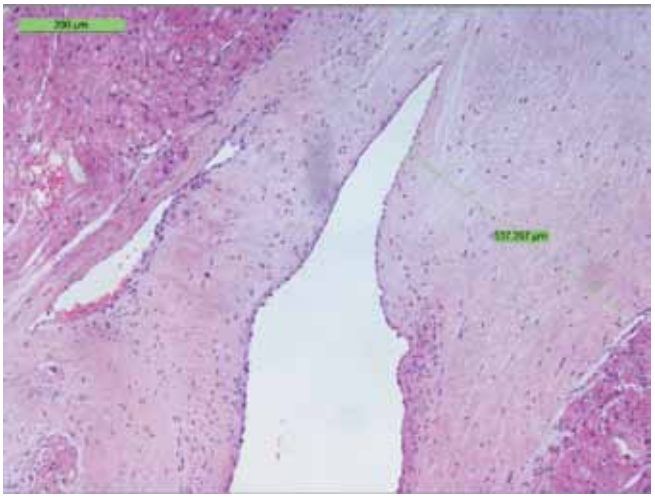

Fig. 3. The expressed sclerosis of the endocardium of the trabeculae in the field of a anterior wall of the left ventricle. H & E stain. ×100

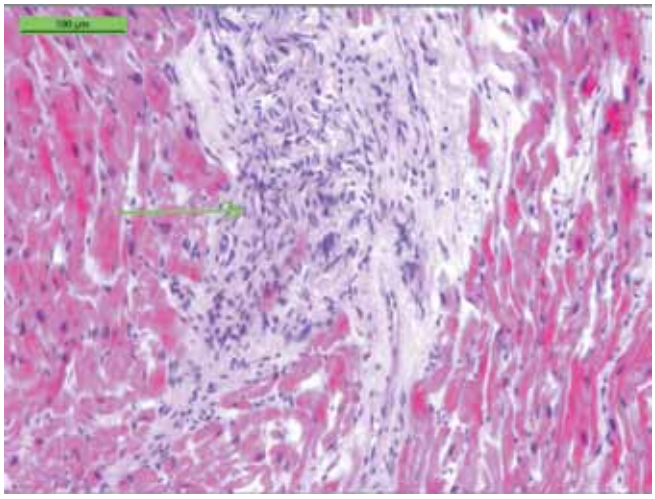

Fig. 4. Nervous fulcrum of the vegetative system in the interventricular septum. H & E stain. ×200

Case No. 2

49-year-old female patient I.E.V. was admitted at Shumakov National Medical Research Center of Transplantology and Artificial Organs, presenting with complaints of weakness, shortness of breath at rest and on minimum exertion, enlarged abdomen, leg swelling. ***Admission diagnosis. Underlying condition:*** *Restrictive cardiomyopathy.* ***Complications of underlying condition:*** *Low left ventricular ejection fraction. Circulatory failure (third degree), NYHA class 3–4.*

Anamnesis morbi. *For a long time, various abnormal heart rhythm, mainly atrial, were observed. Radiofrequency ablation (RFA) – no effect. In 2011, Cox Maze procedure, right atrial isolation, and implantation of epicardial pacemaker were performed. Ascites and edema appeared from September 2012. Shortness of breath for the last three months. Against the background of diuretic therapy, the rate of diuresis decreased, azotemia progressed. Echocardiogram in May 2013 revealed small left ventricular volumes, enlargement of the right parts without signs of pulmonary hypertension. Due to hyperkalemia and azotemia, hemodialysis and ultrafiltration were performed in May-June 2013. The patient was admitted for examination according to heart transplantation program. Oligoanuria persisted, daily hemodiafiltration (HDF) sessions were held.*

Examination upon admission: *Severe condition. Fully conscious. Moves on a chair. Walks with difficulty. Skin with bronze tint, dry, decrease in skin turgor. Swelling of leg, feet and hips. Ascites. Auscultatory vesicular breathing, weakened in the lower parts of the lungs. No wheezing. Respiratory rate = 18 per minute. Rhythmic pulse of reduced filling and tension, without deficiency, heart rate = 90 per minute. Heart sounds are muffled.*

Blood pressure 100/70 mmHg. Abdominal swelling due to unstressed ascites. Liver and kidneys are not palpable. Negative pasternatsky symptom. No dysuric symptoms.

Echocardiogram: LVEDD – 5.4 cm, LVESV – 176, EF – 20%, PAP – 30 mmHg.

Assessment of central hemodynamics: with no nitric oxide – heart rate – 91 bpm, blood pressure – 96/75/69 mmHg, PCWP – 33 mmHg, PAP – 31/22/18 mmHg, TPR – 3.1 Wood units.

The patient was prepared for heart transplant surgery. ***Pre-transplant diagnosis. Underlying condition:*** *Restrictive cardiomyopathy.* ***Complications of underlying condition:*** *Low left ventricular ejection fraction. Circulatory failure (third degree), NYHA class 3–4. UNOS status 1B.* ***Coexisting conditions:*** *Right-sided nephroptosis. Right kidney cyst. Nephropathy. Condition after HDF sessions.*

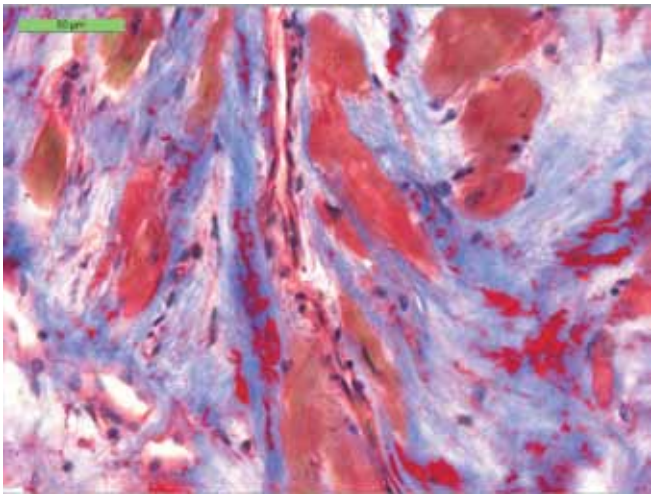

Fig. 5. Dystrophy of the cardiac myocytes and sclerosis of the interstitium with degeneration of the collagen in the inferior wall of the left ventricle. Masson trichrome stain. ×400

Orthotopic heart transplantation with reimplantation of epicardial pacemaker was performed on September 17, 2013.

Pathoanatomical examination of native heart. Macroscopic examination results: *Heart ventricles are excised along the atrioventricular groove, weighing 285 g, measuring 12 × 10.5 × 4 cm. Coronary arteries are wide. Intima of the coronary arteries and their branches are smooth, clean, the arteries are not narrowed throughout. Fibrous ring of the mitral valve is 12 cm in perimeter. Left ventricular wall in the middle sections is 1.2 cm thick. Incised myocardium is brown, in the middle sections of the anterior left ventricular wall with a partial transition to the interventricular septum and a 3 mm thick compact layer in the apex area. The spongy layer reaches 8–10 mm in thickness, deep and wide slits between the trabeculae. The fibrous ring of the tricuspid valve is 10.5 cm in perimeter. The right ventricular wall is 0.4 cm thick. The interventricular septum is 1 cm thick.*

Microscopic examination: *In the anterior and lower left ventricular wall, there is severe degeneration, chaotic and disorderly arrangement of cardiomyocytes in the compact myocardial layer; diffuse focal interstitium sclerosis with collagen degeneration (Fig. 5). The spongy layer also consists of multiple trabeculae with wide intertrabecular spaces (Fig. 6), mild endocardial sclerosis and focal subendocardial fibrosis (Fig. 7). Collagen degeneration was noted in some trabeculae of the anterior left ventricular wall, as in the compact layer (Fig. 8). In the interventricular septum – cardiomyocyte degeneration, diffuse interstitial sclerosis and proliferation of connective tissue around the vessels. In the right ventricular wall, there is degeneration of cardiomyocytes, many hypertrophied cells, as well as a chaotic and disorderly arrangement of cardiomyocytes. Intramyocardial vessels and epicardial vessels – with no*

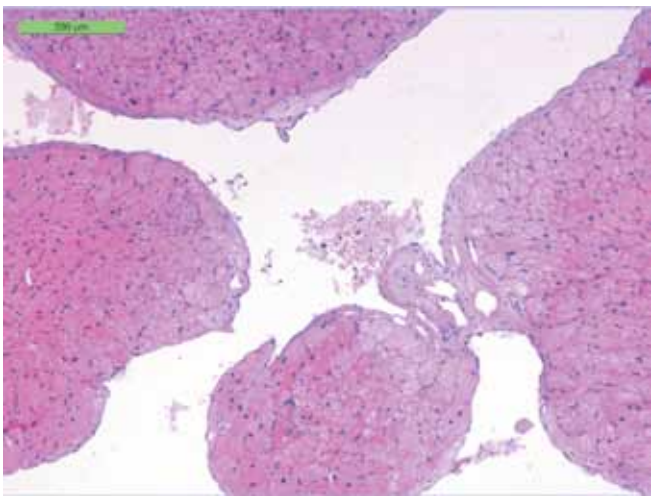

Fig. 6. Trabeculas with wide intertrabeculas spaces in a anterior wall of the left ventricle. H & E stain. ×100

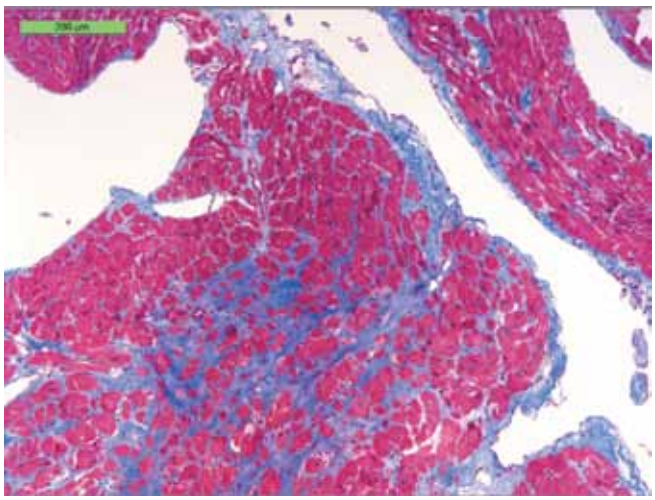

Fig. 7. Diffuse sclerosis of the trabeculas in a anterior wall of the left ventricle. Masson trichrome stain. ×100

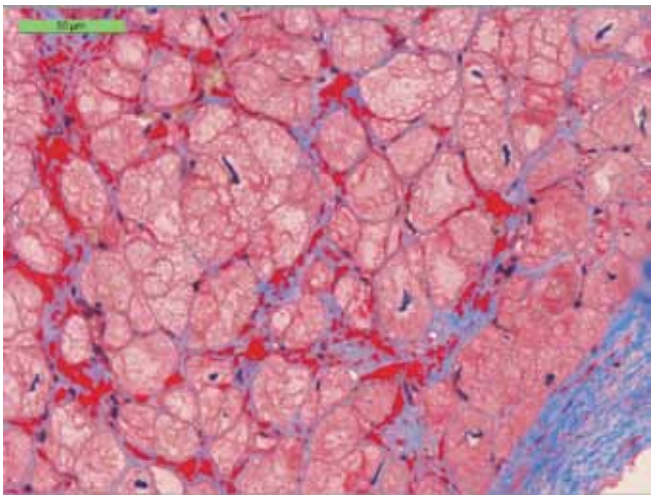

Fig. 8. Dystrophy of the cardiac myocytes and a degeneration of collagen in interstitium of the trabeculas in the free wall of the right ventricle. Masson trichrome stain. ×400

abnormalities. ***Pathoanatomical diagnosis****: Isolated left ventricular noncompaction.*

The patient was transferred from intensive care unit to the ward on day 14 of the postoperative period. ***Definitive clinical diagnosis. Underlying condition:*** *Isolated left ventricular noncompaction.* ***Surgery****. Orthotopic heart transplantation performed on September 17, 2013.* ***Complications of underlying condition:*** *Circulatory failure (first degree), NYHA class 2. Mild iron-deficiency anemia. Condition after HDF sessions.* ***Coexisting conditions:*** *Right-sided nephroptosis. Right kidney cyst. The patient underwent standard therapy.*

Upon discharge on October 30, 2013 and to the present time, the patient's condition has been stable. No complaints.

Case No. 3

31-year-old male patient H.G.M. was admitted at Shumakov National Medical Research Center of Transplantology and Artificial Organs on November 11, 2015 presenting with shortness of breath with minimal physical activity, nocturnal choking episodes, heart failure, weakness.

Anamnesis morbi. *In 2007, when examining the patient for syncope attacks, dilated cardiomyopathy was diagnosed, abnormal heart rhythm was detected as paroxysmal supraventricular tachycardia and paroxysmal unstable ventricular tachycardia. Treatment was performed with beta-blockers, aldosterone antagonists, amiodarone 200 mg per day, disaggregants with no pronounced clinical effect. Deterioration within 2 months, when the signs of heart failure began to progress against the background of drug therapy.*

Admission diagnosis. Underlying condition: *Noncompaction cardiomyopathy.* ***Complications of underlying condition:*** *Right-sided hydrothorax. Chronic heart failure (diastolic). NYHA class III. Abnormal heart rhythm: paroxysmal unstable ventricular tachycardia and paroxysmal supraventricular tachycardia.*

Examination upon admission: *Severe condition due to heart failure. Fully conscious. Can talk. A clear skin, acrocyanosis. Swollen leg and feet. Peripheral lymph nodes are not enlarged. Borders of the heart are expanded to the left by percussion. Heart sounds are muffled, normal rhythm, heart rate is 80 beats per minute. Blood pressure 100/70 mmHg. Pulsation in the arteries of both feet are preserved. Normal chest shape. Borders of the lungs are unchanged. Breathing is free, stiff, occurring in all lobes, weakened in the lower lateral lobes, more on the right, no wheezing. Respiratory rate 24 per min. Tongue is wet, covered with white coating. Abdomen on palpation is soft, painless. Liver +4 cm outward from the edge of the costal arch. No dysuric disorders.*

Echocardiogram: LVEDD – 5.8 cm, LVESV – 179, EF – 25%, PAP – 35 mmHg. Pronounced trabeculation of the cavity and blood clot in the left ventricular apex region, pronounced diffuse hypokinesis.

Spiral CT scan revealed expansion of the heart chambers, blood clots in the projection of the apices of the left and right ventricles, right-sided hydrothorax with compression of the right lung, and also signs of congested liver.

Assessment of central hemodynamics: with no nitric oxide – heart rate – 98 bpm, blood pressure – 99/73/65 mmHg, PCWP – 8 mmHg, PAP – 20/10/15 mmHg, TPR – 1.3 Wood units.

Orthotopic cardiac allotransplantation was performed a week after admission – November 10, 2015.

Pathoanatomical examination of native heart. Macroscopic examination results: *Heart ventricles are excised along the atrioventricular groove, weighing 320 g, measuring 15 × 15 × 4 cm. Intima of the trunk and branches of the left and right coronary arteries are smooth and shiny.*

Fibrous ring of the mitral valve is 13 cm in perimeter. Left ventricular cavity is dilated. Its wall thickness varies from 0.9 to 1.3 cm at various levels. With the exception of the basal sections, there is almost no compact layer, consisting of a trabecular spongy layer. In the intertrabecular spaces of the lower and middle thirds, especially in the apex region, multiple clots of varying degrees of formation are visible, mottled from red to gray (Fig. 9). The right ventricular cavity is also dilated. The fibrous ring of the tricuspid valve is 15.5 cm in perimeter, and the myocardium is 0.1 to 0.2 cm thick. The interventricular septum is 1.1 cm thick, adipose tissue layers are visible from the cut section. ***Microscopic examination:*** *In the anterior and lower left ventricular wall, the myocardium compact layer is less than 1 mm (Fig. 10). The spongy layer includes multiple trabeculae with wide intertrabecular spaces. Trabeculae with severe sclerosis (Fig. 11), degeneration and deterioration of*

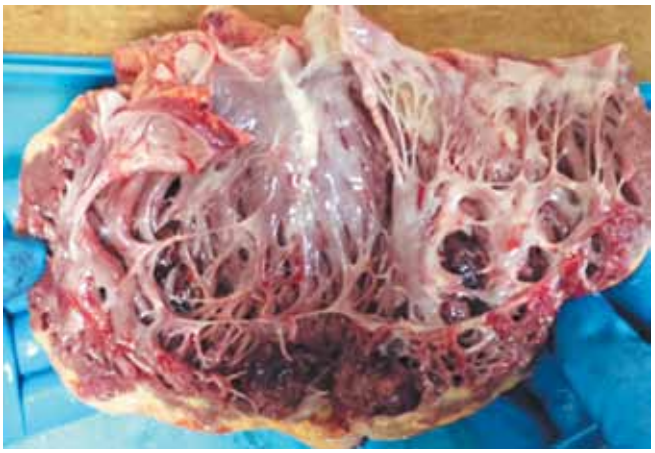

Fig. 9. Removed ventricels of the native heart of the recipient. In figure – an opened cavity of the left ventricle of the heart. Dilated his cavities. In a free wall of the ventricle almost completely there is no compact layer of a myocardium

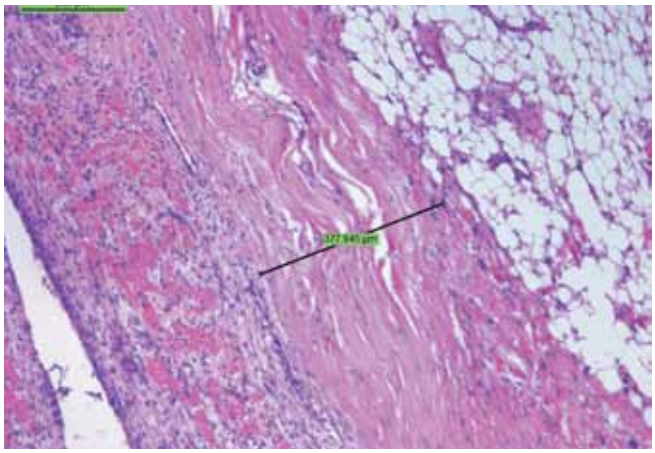

Fig. 10. Extremely thin a compact layer of the inferior wall of the left ventricle. H & E stain. ×100

cardiomyocytes (Fig. 12). In the right ventricular free wall, there is also interstitial sclerosis with collagen and cardiomyocyte degeneration. In the interventricular septum, myocardial sclerosis is less pronounced. At the same time, sympathetic trunks of the autonomic nervous system appear to be enclosed in the connective tissue layers. Along with connective tissue proliferation in the interventricular septum, a significant content of fatty tissue was noted (Fig. 13). ***Pathoanatomical diagnosis:*** *Isolated left ventricular noncompaction.*

Since the patient was discharge on December 15, 2015, and to the present time, his general condition and graft function have remained satisfactory. No complaints.

DISCUSSION

At our research center, patients who have congestive heart failure caused by dilated or ischemic cardiomyo-

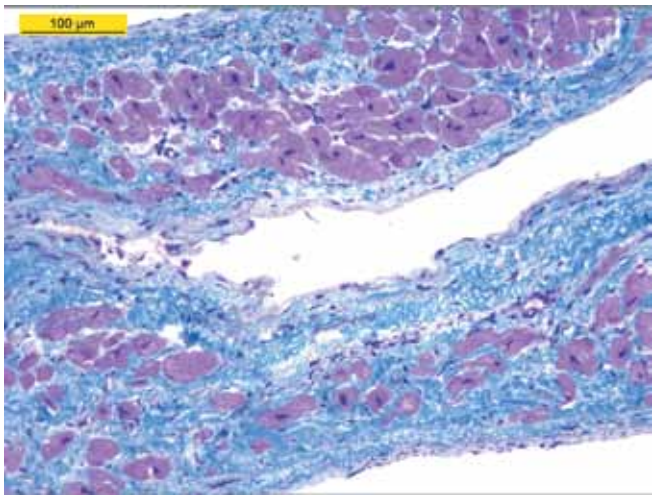

Fig. 11. The expressed sclerosis of the endocardium and of the interstitium, and also an atrophy of the cardiac myocytes of the trabeculas in the anterior wall of the left ventricle. Masson trichrome stain. ×200

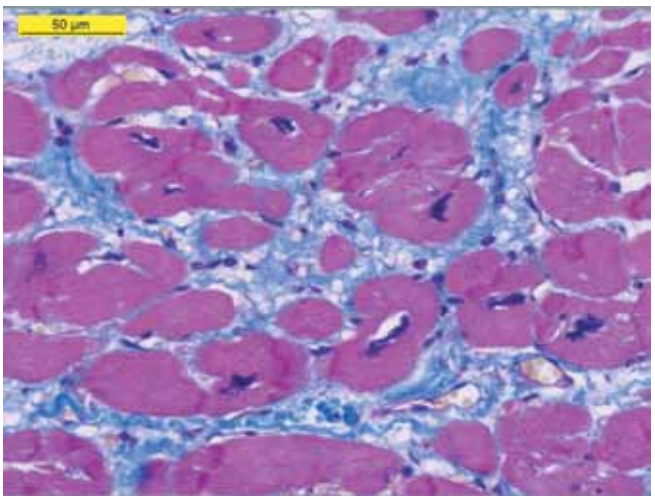

Fig. 12. Ttrabecula in a anterior wall of the left ventricle. The expressed dystrophy of the cardiac myocytes with perinuclear edema and hyperchromatosis of the misshapen nucleus. Masson trichrome stain. ×400

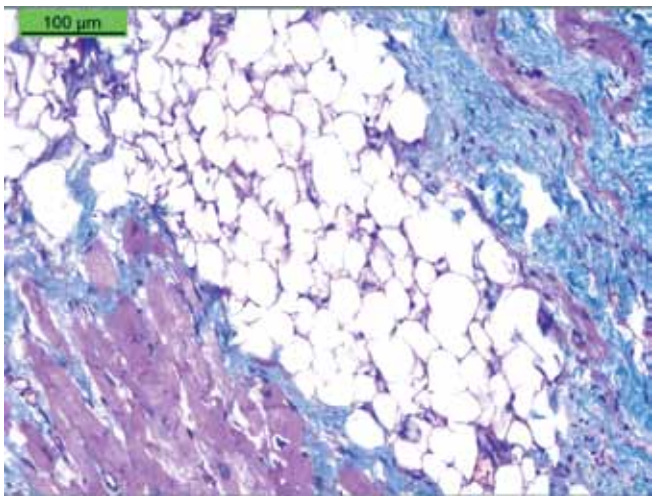

Fig. 13. Fatty tissue and sclerosis of the interstitium in the interventricular septum. Masson trichrome stain. ×200

pathy are the main group in the heart transplant waiting list. However, over the past decade, heart transplant has been performed for patients suffering from other heart diseases, particularly, such a rare condition as isolated LVNC. From 1986 to December 25, 2019, about 1,413 heart transplants were performed at our research center. Isolated non-compaction of the left ventricular myocardium was diagnosed via echocardiogram and spiral CT scan and morphologically confirmed in only three patients, which is only 0.2%. Based on available reports [4, 5, 16, 17], only 10 cases of heart transplant in adults suffering from isolated LVNC have been published to date.

The difficulty in diagnosing isolated LVNC, which many authors discuss [6–9], can be noted in the cases we have cited. Two patients (cases 1 and 3) were for a long time diagnosed with dilated cardiomyopathy. It was only at the stage of development of end-stage heart failure in one patient (case 1) that the right clinical diagnosis was made before heart transplantation. In the other patient (case 3), right clinical diagnosis was made only during hospitalization at our research center. One of the patients (case 2), right up to heart transplantation, was diagnosed with restrictive cardiomyopathy. The correct diagnosis, isolated LVNC, was made only after morphological examination.

According to some reports [6–8], it is necessary to conduct a particularly thorough differential diagnosis of isolated LVNC with dilated cardiomyopathy, in which dilatation of the left ventricular cavity is accompanied by a thinning of the myocardium compact layer, which gives the impression of hypertrabeculation. On the contrary, with isolated LVNC, left ventricular cavity dilatation can lead to erroneous diagnosis of dilated cardiomyopathy [6]. W.C. Roberts et al. [7], reporting about cardiac transplantation done in 3 patients (2 women), aged 36, 45, and 49 years for what was diagnosed clinically as nonischemic dilated cardiomyopathy, noted hypertrabeculation involving the free wall of the dilated left ventricle. In their own observations, the authors talk about isolated LVNC. However, they believe that analysis of gross photographs of the heart from previous publications by other authors suggests that isolated LVNC is overdiagnosed at least morphologically [7]. This thesis is confirmed by M. Zhang et al. [8], who examined 64 native heart transplant patients with a clinical diagnosis of dilated cardiomyopathy; five of these patients had a mildly noncompacted left ventricle with hypertrabeculation.

Patients with isolated LVNC rarely need a heart transplant surgery. This is determined by the severity of refractory congestive heart failure. It can occur in infants and may be absent even in adults. Moreover, many patients with isolated LVNC are asymptomatic [4, 18]. In all the three heart transplant cases at our research center, the patients suffered from congestive heart failure associated with isolated LVNC.

Preparation for surgery, heart transplant technique and post-transplantation management of patients suffering from isolated LVNC do not differ from the general cohort of transplant patients, but nevertheless require a personalized approach.

CONCLUSION

Isolated left ventricular noncompaction is a rare condition that has not been well publicized in scientific literature. It can occur without symptoms and cause severe refractory congestive heart failure that necessitates a heart transplant surgery.

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REFERENCES

1. *Hook S, Ratliff NB, Rosenkranz E, Sterba R.* Isolated noncompaction of the ventricular myocardium. *Pediatr Cardiol*. 1996; 17: 43–45.
2. *Agmon Y, Connolly HM, Olson LJ, Khandheria BK, Seward JB.* Noncompaction of the ventricular myocardium. *J Am Soc Echocardiogr*. 1999; 12: 859–863.
3. *Shah CP, Nagi KS, Thakur RK, Boughner DR, Xie B.* Spongy left ventricular myocardium in an adult. *Tex Heart Inst J*. 1998; 25: 150–151.
4. *Conraads V, Paelinck B, Vorlat A, Goethals M, Jacobs W, Vrints C.* Isolated non-compaction of the left ventricle (a rare indication for transplantation). *J Heart Lung Transplant*. 2001; 20: 904–907.
5. *Stamou S, Lefrak E, Athari FC, Burton NA, Massimiano PS.* Heart transplantation in a patient with isolated noncompaction of the left ventricular myocardium. *Ann Thorac Surg*. 2004; 77: 1806–1808.
6. *Shumakov V, Khubutiya M, Iljinsky I.* Dilated Cardiomyopathy. M., 2003. 448 p.
7. *Roberts WC, Karia SJ, Ko JM, Grayburn PA, George BA, Hall SA et al.* Examination of isolated ventricular noncompaction (hypertrabeculation) as a distinct entity in adults. *Am J Cardiol*. 2011 Sep 1; 108 (5): 747–752. doi: 10.1016/j.amjcard.2011.04.027. Epub 2011 Jul 1.
8. *Zhang M, Tavora F, Huebner T, Heath J, Burke A.* Allograft pathology in patients transplanted for idiopathic dilated cardiomyopathy. *Am J Surg Pathol*. 2012 Mar; 36 (3): 389–395. doi: 10.1097/PAS.0b013e31823b02f5.
9. *Szymanski C, Otmani A, Leborgne L et al.* Ventricular tachycardia revealed by a left ventricular non-compaction. *Annales de Cardiologie et d'Angeiologie*. 2007; 56 (6): 319–323. View at Publisher. View at Google Scholar. View at PubMed.
10. *Greutmann M, Mah ML, Silversides CK, Klaassen S, Attenhofer Jost CH, Jenni R, Oechslin EN.* Predictors of adverse outcome in adolescents and adults with isolated left ventricular noncompaction. *Am J Cardiol*. 2012 Jan 15; 109 (2): 276–281. doi: 10.1016/j.amjcard.2011.08.043. Epub 2011 Oct 28.
11. *Cavusoglu Y, Ata N, Timuralp B et al.* Noncompaction of the ventricular myocardium: report of two cases with bicuspid aortic valve demonstrating poor prognosis and with prominent right ventricular involvement. *Echocar-*

diography. 2003; 20 (4): 379–383. View at Publisher. View at Google Scholar.
12. *Chenard J, Samson M, Beaulieu M.* Embryonal sinusoids in the myocardium (report of a case successfully treated surgically). *Can Med Assoc J*. 1965; 92: 1356–1359.
13. *Robida A, Hajar HA.* Ventricular conduction defect in isolated noncompaction of the ventricular myocardium. *Pediatr Cardiol*. 1996; 17: 189–191.
14. *Spieker T, Krasemann T, Hoffmeier A, Buning A, Debus V, Kehl H et al.* Heart transplantation for isolated noncompaction of the left ventricle in an infant. *Thorac Cardiovasc Surg*. 2007 Mar; 55 (2): 127–129.
15. *Zuckerman WA, Richmond ME, Singh RK, Carroll SJ, Starc TJ, Addonizio LJ.* Left-ventricular noncompaction in a pediatric population: predictors of survival. *Pediatr Cardiol*. 2011 Apr; 32 (4): 406–412. doi: 10.1007/s00246-010-9868-5. Epub 2010 Dec 25.
16. *Bordes J, Jop B, Imbert S, Hraiech S, Collard F, Kerbaul F.* Case Report A Rare Cause of Heart Failure Treated by Heart Transplantation: Noncompaction of the Ventricular Myocardium. *Case Reports in Medicine.* Volume 2009, Article ID 725879, 3 pages. doi: 10.1155/2009/725879.
17. *Said S, Cooper CJ, Quevedo K, Rodriguez E.* Biventricular non-compaction with pre-dominant right ventricular involvement, reduced left ventricular systolic and diastolic function, and pulmonary hypertension in a Hispanic male. *Am J Case Rep*. 2013 Dec 13; 14: 539–542. doi: 10.12659/AJCR.889676. eCollection 2013.
18. *Captur G, Nihoyannopoulos P.* Left ventricular noncompaction: genetic heterogeneity, diagnosis and clinical course. *Int J Cardiol*. 2010 Apr 15; 140 (2): 145–153.
19. *Uribarri A, Rojas SV, Avsar M, Hanke JS, Napp LC, Berliner D et al.* First series of mechanical circulatory support in non-compaction cardiomyopathy: Is LVAD implantation a safe alternative? *Int J Cardiol*. 2015 Oct 15; 197: 128–132. doi: 10.1016/j.ijcard.2015.04.046. Epub 2015 Apr 7.

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