CORONARY ARTERY PATHOLOGY IN CHILDREN. CAUSE-AND-EFFECT FACTORS AND METHODS OF DIAGNOSTICS

I.V. Andrushchenko
SU «Institute of Nuclear Medicine and Radiology NAMS of Ukraine», Kiev

The current views on the coronary artery pathology as the cause of myocardial infarction in children are presented. The radiological methods of diagnosis of these conditions at the present stage are covered.
Key words: children, coronary artery anomalies, coronaritis, echocardiography, MDCT and MRI.

Coronary artery anomalies and disorders is a little-studied branch of Pediatric Cardiology. These conditions can be a reason of myocardial infarction in children, the factor limiting the lifespan. They are associated with a high risk of sudden cardiac death in children. Pediatricians practically do not know the cause of myocardial infarction in children, which, in turn, hinders the timely diagnosis of disease. Myocardial infarction in children until recently was considered casuistry. According to the data of the Center for Disease Control and Prevention (CDC), the mortality rate from myocardial infarction in the USA is 0.2 cases per 100,000 population among persons aged 15–24 years among which are predominantly male (80%), and less than 0,2 per 100,000 of population — at the age of 1 year. For comparison, the death rate from myocardial infarction in persons aged 25–34 years was 1,4 per 100,000 population and 262.0 per 100,000 in persons aged 65–74 years [19,27]. The U.S. National Library of Medicine specifically detects every case of myocardial infarction in the childhood, which is described in the world medical literature. [5].

To the coronary artery pathology in children belongs the anomaly of coronary artery origin — congenital pathology of coronary arteries; Kawasaki disease, polyarteritis nodosa, giant cell arteritis, idiopathic arterial calcification, inflammatory diseases of coronary artery of rheumatic genesis, secondary vasculitis — acquired pathology of the coronary artery.

The most common reason of myocardial infarction development in children is congenital anomalies of coronary artery development, due to the peculiarities of embryonic coronary system development. Classification of congenital anomalies of the coronary artery is: [14,28]

1. Entrance anomalies.
2. Ectopic origins of coronary artery:

a) anomalous origin of coronary artery from the pulmonary artery;
b) anomalous origin of coronary artery from the aorta;
c) anomalous origin of coronary artery from other coronary artery;
d) anomalous origin of coronary artery from extra cardiac vessels;
e) anomalous origin of coronary artery from the ventricular chamber.

3. Intramural course of coronary artery («diving» coronary artery).
4. Anomalies of the distal compounds of coronary artery (coronary fistulas).
5. Anomalies of a number of coronary arteries.
6. Hypoplasia of coronary artery.

Let's consider the most frequent nosology.

According to the literature data among the presented pathology the domination belongs to ectopic origins of coronary artery and also to anomalous origin of the left coronary artery (AOLCA) from the pulmonary artery; (Bland—White—Garland syndrome — B-W-G syndrome), 0.025–0.05 per 1000 newborns, 0.22% — among all congenital heart diseases (CHD) and 0.4–0.7% — among critical CHD [2,14]. There are two types of anomalous origin of coronary artery from the pulmonary artery:

1. Infantile type — with poorly developed collaterals in coronary artery;

2. Adult type — with a well-developed collateral circulation in the coronary artery. [7].

Hemodynamics at AOLCA from pulmonary artery

exclusively connected with the well or badly-developed anastomoses system, as blood flows into the left coronary artery not from the pulmonary artery, but from right across the intracoronary collaterals. This fact determines the survival rate of these children. At the «infantile» type the myocardial perfusion is distinctly not enough, and severe ischemia of supplied by present vessel area develops at 6–8 weeks after birth. As a result, appears myocardial infarction development and death occurs.

At the «adult» type the myocardial perfusion determined by the degree of anastomosis development and often detected in preschool or even adulthood age [5,7].

Accurate diagnostic of AOLCA from the pulmonary artery, like all congenital and acquired diseases of coronary artery, is possible only during the use of the methods of radiology. Each method has certain advantages and disadvantages. Any examination of children with cardiac pathology by radiological method begins from the routine review of the direct radiography of the chest organs. As a rule, during these pathological conditions the cardiomegaly is defined, which at the same time can get to such point when the picture show the darkening of all left half of the chest, and stagnation in the lungs [7,11].

For the present days echocardiography (ECG) continues to be the most common, non-invasive and affordable method of heart study. The conduction of ECG at AOLCA of pulmonary artery is means visualization of the aortic root with coronary artery entrance. Some technical difficulties in obtaining ultrasonic section of the left coronary artery of the pulmonary trunk should be marked, especially in infants with cardiomegaly of unknown etiology, which excludes in the most cases the diagnosis of anomalous origin of a coronary artery. There are nonspecific symptoms defined as usual: dilatation of the left ventricle with the signs of global hypokinesia with anomalous wall motion segments, often — mitral regurgitation [7].

It is known that catheterization of heart cavities and coronary angiography (CAG) has been the «gold standard» in the diagnosis of CHD and vessels until recently. Also, during the present study the conduction of intracardiac injection of contrast agent is often leads to the severity of the patient's condition.

In this regard, the interest to find more informative, sensitive and less invasive methods of diagnosis in pediatric cardiology are presented. [12] Therefore, at the present day the most informative and accessible methods for diagnosis of ectopic origin of a coronary artery is an X-ray computed tomography (CT). At the present stage of development of radiology it is multidetector computed tomography (MDCT) and magnetic resonance imaging (MRI). These methods allow not only clearly define the place of coronary artery origin, but also to identify heart comorbidities and its blood vessels [1,3,5,18,21,26].

This pathology in all cases requires surgical correction. There is a wide range of surgical procedures — from the elimination of anomaly development to aorto-coronary bypass. Deficiency prognosis without operation is extremely unfavorable. In the first year of life without treatment are dying 2/3 of the patients, survive to older age not more than 15% in the future 50% — suddenly after physical or psychological and emotional stress [2,7].

Besides birth defects of a coronary artery to the myocardial infarction leads acquired pathology of coronary artery — coronaritis. At present days in the native literature there are no data on their prevalence. This is, most likely, connected with the difficulties in vivo diagnosis. As a rule, diagnosis is conducted only at autopsy.

All coronaritis are common in the complexity of diagnosis and the overall clinical picture — it is development of acute coronary syndrome (ACS) [11,16,17] Thus, at the present time in the USA, Japan, Europe the disease (syndrome) Kawasaki (KD) is recognized as the leading factor of acquired heart disease in children [20]. This is the primary systemic vasculitis of unknown etiology with the mainly affect of the coronary artery. The disease occurs most often in the age from 2 months to 8 years, 80% of patients with KD — children under 4 years, the top level of incidence occurs in the age of 2 years [7,11,16,25,27,28]. In the USA the incidence amounts 10 per 100,000 children under 5 years of age (not Asians), 44 children per 100,000 (Asians). Mortality is amount for about 1% [4,8]. The particularity of KD is the presence of coronary artery aneurysms in combination with stenosis and areas of obliteration and also dilated distensions on extended area without aneurysm formation [6,23]. It is marked staging of changes of vessel wall: necrosis, obliteration, aneurismal formations. In the absence of adequate treatment coronary artery aneurysms are developed from the 10th day to 4 to 6 weeks of the disease in 15–25% of patients [11,16,22]. But even in the set-

ting of treatment approximately in about 5% of patients the coronary artery aneurysms are formed, and 1% — it is giant aneurysms. [20] According to the recommendations of the American Heart Association, coronary artery aneurysms divided into small (internal diameter less than 5 mm), medium (5–8 mm internal diameter) and giant (internal diameter greater than 8 mm) [9]. Small aneurysms disappear in the first 2 years after undergoing KD at the same time the walls of coronary artery do not thicken. In the remaining aneurysms were marked the signs of fibrosis and calcification which is leading to the formation of stenosis or to the formation of intracoronary thrombus occlusions that, in turn, leads to myocardial infarction [20,23,29]. And according to the follow-up observations of Suzuki A. et al., Tsuda E. et al. a very serious problem during the KD is further progress of stricture formation of coronary artery [23,29].

Today for visualization of coronary artery aneurysms we are able to use different non-invasive radiological techniques: echocardiography, MDCT and MRI.

Transthoracic echocardiography allows determining aneurysm of proximal sections of coronary arteries, where they often formed. According to the literature, the sensitivity of transthoracic echocardiography in detecting of aneurysms proximal segments of the left and right coronary artery is 96–100%, distal segments — up to 83%, specificity — 96–100%. [9] Besides this, present method allows evaluating the presence of pericardial effusion in the cavity, the state of the valve apparatus, systolic, diastolic functions of the left ventricular function, as in the acute phase of the disease in the pathological process can be involved the pericardium, myocardium, endocardium, valvular apparatus and also cardiac conduction system. In the presence of administration echocardiography allow conducting daily dynamic monitoring with the aim of timely detection of life-threatening complications — the increase of heart failure.

The role of MDCT and MRI increases in the certain long-term observation, it is due to their high sensitivity in the diagnosis of stenosis and occlusions of coronary artery [18,20,26]. The data of Suzuki A. et al. are shown that occlusive lesions of coronary artery occur in the first 2 years after the acute phase and are due to coronary artery thrombosis (up to 80% of all occlusions), in other cases (20%) it is the consequence of intimal thickening [29].

MDCT of the coronary artery is a non-invasive method which has allowed estimate with the accurately assess the condition of the coronary bed. The main advantages in comparison with CAG are noninvasiveness and opportunity to evaluate not only intraluminal clearance, but also the state of the vessel wall, that is important during the estimation of the aneurismal lesions. Radiation exposure at MDCT on the modern apparatus is much lower than during the CAG. Typically, the research is carried out without sedation and anesthesia. For the restless children and infants the use of minimal sedation is more applicable. For obtaining of high-quality images of the coronary arteries patient need to have sinus rhythm with a frequency no less than 90 beats/min.

MRI is also a non-invasive method that allows us to investigate coronary artery not associated with radiation exposure. High temporal resolution, the ability to conduct research without breath appropriate, to use MRI to examine patients of younger age group, including children of the first year of life [6,26].

Currently, the main method of the treatment of KD is the combination of immunoglobulin for intravenous intake (IVIG) and acetylsalicylic acid.

In patients with coronary aneurysms in the course of time the state of coronary artery can be changed. The disappearance of the aneurysm after 1–2 years from the onset of disease, by the data of coronary angiography, is observed approximately in 50–60% of affected segments of the vessels [6]. However, in the «restored» arteries remain histological and functional changes [20,24].

A serious problem encountered in the follow-up care of patients after KD, such as the progression of the local coronary artery stenosis. Despite the presence of severe stenosis, patients rarely have symptoms of ischemia, some patients die suddenly [10,29].

According to the data of E. Tsuda et al. coronary artery stenosis after 5, 10 and 15 years after undergoing of KD in 44, 62 and 74% respectively is found in patients with giant aneurysms, in patients with the middle aneurysms — in 6, 20 years and 58% in patients with small aneurysms of coronary artery stenosis is not observed [23].

The probability of atherosclerotic lesions of the coronary vessels in adults who had KD in childhood is much higher, as well as endothelial dysfunction, even if they had no coronary aneurysms. Therefore, it is necessary to take under control such patients, as

a long-term risk of cardiac disorders is unknown and requires study [6].

To the post-inflammatory changes of coronary artery also lead such disorders as giant cell arteritis (temporal or cranial or temporal arteritis). The typical for it mainly thrombosis of a coronary artery, which can lead to myocardial infarction, but also may be formation of multiple aneurysms as a result of destruction of elastic fibers of vessel walls.

Nonspecific aortoarteritis (disease (syndrome) Takayasu). Coronary artery in patients is affected in about 20–25% of cases [7]. This complication is potentially unfavorable up to fatal due to changes of the proliferative nature of intima, fibrosis of the media and adventitia. The proximal segments of coronary artery are affected. The reason of pathological changes is a coronary insufficiency, which is lead to myocardial infarction.

Idiopathic arterial calcification (congenital coronaritis) – it is congenital vascular calcification which is caused by a hereditary deficiency of elastic membranes of the arteries. Disease is characterized by generalized calcification of the inner and middle shells of coronary artery and vessels of all body. In severe cases it leads to sclerosis, stenosis, up to coronary artery occlusion and as a consequence to ACS. Present disease is customary for infants.

For polyarteritis nodosa is typical formation of coronary artery aneurysms.

It should be noted that during the arteritis coronary arteries are not the main «target.» Thus, during the giant cell arteritis the temporal artery, the artery of the retina and brain are mainly affected. For nonspecific aortoarteritis the primary importance has aorta defeats and its branches. Main arteria-targets in polyarteritis nodosa are vessels of the kidneys.

In conclusion, it is needed to be marked that myocardial infarction is not only a consequence of coronary atherosclerosis changes of the coronary arteries in the adult population. Myocardial infarction has no age restrictions. Early diagnosis of diseases which are leading to the development of acute coronary syndrome in children (abnormalities of the coronary arteries, coronaritis) is possible with the help of modern methods of radiology, which in turn will improve the prognosis of disease, reduce mortality and reduce disability of patients. All the more for the pediatric community «a priori» the manifestations of adult diseases start from the childhood.

References

1. Bagmanova Z.A. Koronarolevozheludochkovaya fistula. Ultrazvukovaya i funktsionalnaya diagnostika. 2010; 2: 88—93.
2. Belozerov Yu.M. Detskaya kardiologiya. M: MEDpress-inform, 2004: 597.
3. Sukhareva G.E., Imnadze I.N., Ustenko L.I. [at al.] Bolezni koronarnykh arteriy u detei. Tavricheskiy mediko-biologicheskiy vestnik. 2003; 2: 222—230.
4. Volosovets A.P., Krivopustov S.P. Insul't golovnogo mozga i infarct miokarda u detei: sovremennyi vzglyad na problemu. Zdorov'e rebyonka. 2006; 2: 63—69.
5. Leontiev I.V., Tsaregorodtseva L.V., Belozerov Yu.M. [at al.] Infarkt miokarda u detei: vozmozhnye prichiny, sovremennye podkhody k diagnostike. Pediatriya. 2001; 1: 32—37.
6. Lyskina G.A., Vinogradova O.I., Shirinskaya O.G. [at al.] Klinika, diagnostika i lechenie sindroma Kawasaki: klin. rekomendatsii. M., 2011: 57.
7. Leontieva I.V. Lektsii po kardiologii detskogo vozrasta. M.: Medpraktika-M, 2005: 535.
8. Lyskina G.A., Shirinskaya O.G. Slizisto-kozhnyi limphonodulyarnyi sindrom (sindrom Kawasaki). Diagnostika i lechenie. M: Vidar, 2008: 144.
9. Sukhareva G.E., Yalynskaya T.A., Kaladze N.N. [et al.] Opyt primeneniya magnitno-rezonansnoi tomografii v detskoi kardiologicheskoi praktike. Klinichna pediatriya. 2010; 4 (25): 67—72.
10. Panichkin Yu.V., Kuzmenko D.A., Levchishina E.V. Bolezn' Kawasaki kak prichina infarkta miokarda. Sertse i sudyny. 2009; 2 (26): 106—110.
11. Shirinskaya O.G., Lyskina G.A., Tarasova A.A. [at al.] Resultaty dinamicheskogo nablyudeniya patsientov s sindromom Kawasaki po dannym transtorakal'noi ekhokardiografii, multispiral'noi kompyuternoi tomografii i koronarnoi angiografii. Ultrazvukovaya i funktsional'naya diagnostika. 2011; 1: 47—55.
12. Sukhareva G.E., Iemets I.N., Kaladze N.N. [at al.] Rol' sovremennykh metodov vizualizatsii v diagnostike slozhnykh vrozhdyonnykh porokov serdtsa u detei. Klinichnapediatriya. 2010; 1(22).
13. Murzina O.Yu., Kovalev I.A., Varvarenko V.I. [at al.] Sluchai nespetseficheskogo aortoarteriita u detei 3. Sovr. Tekhnologii v pediatrii i detskoi khirurgii: mater. V pos. kongressa. — M: Overley, 2006: 176—177.

14. Sukhareva G.E., Lagunova N.V., Rudenko N.N. Ostryi koronarnyi sindrom kak pediatricheskaya problema. Chast' I. Zdorovie rebenka. 2007; 4 (7).
15. G.E. Sukhareva G.E., Lagunova N.V., Rudenko N.N. Ostryi koronarnyi sindrom kak pediatricheskaya problema. Chast' II. Zdorovie rebyonka. 2007; 5(8): 102—106.
16. Shirinskaya O.G., Tarasova A.A., Lyskina G.A. [at al.] Transtorakalnaya echocardiographiya v diagnostike anevrizm koronarnykh arteriy u detei s sindromom Kawasaki. Ultrazvukovaya i funktsionalnaya diagnostika. 2010; 1: 43—52.
17. Shirinskaya O.G., Tarasova A.A., Lyskina G.A. Ultrazvukovoe issledovanie koronarnykh arteriy u detei. Ultrazvukovaya i funktsionalnaya diagnostika. 2008; 4: 76—87.
18. Tacke C.E., Kuipers I.M., Groenink M. [et al.].Cardiac magnetic resonance for noninvasive assessment cardiovascular disease during the follow-up of patients with Kawasaki disease Circ Cardiovascular Imaging Nov 1. 2011; 4 (6): 712—720.
19. CDC. National Vital Statistic Report: Acute myocardial infarction. 1998, Nov.; 47 (9).
20. Newburger J.W., Takahashi M., Gerber M.A. [et al.] Diagnosis, treatment and long-term management of Kawasaki disease: a statement for health professionals from the Committee on Rheumatic Fever, Endocarditis, and Kawasaki Disease, Council on Cardiovascular Disease in the Young, American Heart Association. Pediatrics. 2004; 114: 1708—1733.
21. Gasit A.Z., Avari J.N., Baizer D.T. [et al.] Electrocardiographic diagnosis of myocardial ischemia in children: is a diagnostic electrocardiogram always diagnostic? Pediatrics. 2007, Aug.; 120 (2): 440—444.
22. Fukuda T., Ishibashi M., Shinohara T. [et al.] Follow-up assessment of the collateral circulation in patients with Kawasaki disease who underwent dipyridamole stress technetium-99m tetrofosmin scintigraphy. Pediatr Cardiool. 2005, Sep.—Oct.; 26 (5): 558—564.
23. Tsuda E., Kamiya T., Ono Y. [et al.] Incidence of stenotic lesions predicted by acute phase changes in coronary arterial diameter during Kawasaki disease. Pediatr Cardiol. 2005; 26: 73—79.
24. Iemura M., Ishii M., Sugimura T. [et al.] Long term consequences of regressed coronary aneurysms after Kawasaki disease: vascular wall morphology and function. Heart. 2000; 83: 307—311.
25. Louis B. Stuart Berger Myocardial infarction in Childhood. Medscape. 2011.
26. Suzuki A., Takemura A., Inaba R. [et al.] Magnetic resonance coronary angiography to evaluate coronary arterial lesions in patients with Kawasaki disease. Cardiol. Young. 2006; 16: 563—571.
27. Mahle W.T., Campbell R.M., Favaloro-Sabatier J. Myocardial infarction in adolescents. Pediatrics. 2007, Aug.; 151 (2): 150—154.
28. Park M.K., Troxler R.G. Pediatric Cardiology for Practitioners. 4-th ed.: Monography. London: Mosby, 2002: 192—193.
29. Suzuki A., Miyagawa-Tomita S., Nakazawa M. [et al.] Remodeling of coronary artery lesions due to Kawasaki disease: comparison of arteriographic and immunohistochemical findings. Jpn. Heart J. 2000; Vol. 41: 245—256.
30. Wayne D.R., Lloyd E.C., Gerardo H. [et al.] Twenty-Two-Year Trends in incidence of Myocardial infarction, Coronary Heart Disease Mortality and Case Fatality. 4 US Communities, 1987—2008 Circulation. 2012; 125: 1848—1857.