Radiological Examination Methods of Cardiovascular Disease

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ABSTRACT

Nowadays the methods of radiology are at a very high scientific level. In our presentation, we discuss the possibilities of better prevention using radio-diagnostic procedures. In spite of the several risk factors which restrict in many cases the patient’s successful treatment process, there are progressive improving radiology examinations which contribute to early diagnosis. For achievement of these aims, it is necessary to increase the education level of the Radiology Staff and to innovate the equipment status in the Radiology Departments.

Key Words: cardiovascular disease, prevention, risk factors, congenital heart defects, radiology

Introduction

Health status is affected by genetic features; availability of health care; living and working conditions; as well as by socio-economic conditions. Health greatly affects the way of live of individuals and their lifestyle. Lifestyle and attitude to their own health are created during a person’s life, depending on many factors such as education, culture, stereotype, comfort, etc. (Report on the Health Status of the Population of the Slovak Republic for the years 2009-2011, p. 60)

The most basic rule is mainly to maintain a healthy lifestyle; which is to eliminate smoking, obesity, lack of physical activity, as well as the impact of stress on the body. Known number of lifestyle are 0-30-5-140-90, which means 0 - cigarettes, 30 minutes of physical activity a day, 5 - healthy level of total cholesterol and 140^90 means maximum blood pressure. Experience shows that there is a link between risk factors and their removal can reduce the incidence of cardiovascular disease, but it is not scientifically proven. (Dudeková, 2012)

Mačkinová (2013) indication that although Medicine, Nursing, Social Work and other Departments show considerable progress; a human approach should not be underestimated.

1. Hospitalization, Hospitalized Patients

In 2012, hospitalization for circulatory diseases, including patients with transient ischemic attack (TIA: G45) indicated 138,045 patients whose hospital stay was requested, all together 182,653 hospitalizations. For acute conditions within circulatory diseases, and for acute coronary syndrome (ACS: I 20 – I 22) 15,289 patients were hospitalized for stroke (stroke: I 60 – I 64), including patients with TIA 19,076 patients. (Health Statistical Yearbook Slovakia 2012, p. 40)
2. Incidence

The standardized incidence rate for ACS and stroke was on the 2009 level. The national health registries of ACS and stroke reported, 4,652 patients with ACS episode (only 30% of hospitalizations) and 7,713 patients with stroke (40% of relevant patients) in 2012. Due to the persistent low number of cases, the database of hospitalized patients is the most objective source of ACS and stroke incidence. (Health Statistical Yearbook Slovakia 2012, p. 40)

Caring for patients with cardiovascular disease (CVD) requires a comprehensive approach and an approach that consists of early diagnosis, evaluation of prognostic factors, and the introduction of adequate treatment and ongoing monitoring of the disease course. Protocols to ascertain the relationship between the specificities which arise at an earlier age are at high risk of disease.

Protocols for preventive examinations would bring enormous progress in the management of patients. Each patient in whom a diagnosis of some form of CVD was detected will be examined by available non-invasive examination methods. Genetic screening is complicated, but allows a preventative action without genetic risk of developing CVD. Therefore, it is important that investigations are carried out before the outset of the disease. With the consistent application of knowledge in practice, it can be expected that in the near future these patients will be recorded in Slovakia.

There is the assumption that the treatment will be carried out in future generations according to guidelines (recommendations) and thus will represent actual prevention of CVD.
Graph. No. 2 Number of hospitalizations for selected diagnoses diseases of the circulatory system (Source: Health Statistical Yearbook 2012, p. 53)

3. Stress and the Cardiovascular System

Stress

- The reaction of the organism to changes in internal or external environment
- The purpose of the stress response is the body adaptation to changes
- Inability to adapt to adjustment to causes of disorders with severe damage to and destruction of the body

The cause of the disease is a predisposing factor which increases the propensity to disease by reducing resistance; lack of recovery; inadequate efforts to adapt.

Stress reaction is accompanied by an increased level of catecholamines which have a significant affinity to the myocardium. The result is tachycardia and an increase in myocardial contractility, minute volume and oxygen consumption. During the stress response most frequent pathological responses of cardiovascular system disorders involve arrhythmias and regional coronary flow. (Kölbel, 1985)

Congenital Heart Defects

Congenital heart defects are defined as disorders affecting the structure and function of the heart that occur during intrauterine development, but usually do not become apparent until after birth.
Data processing that deals with the National Health Information Center:

A long-term purpose is to collect selected clinic-epidemiological data on patients with congenital heart disease; to process information on morbidity and mortality of cardiovascular diseases; on the trends of these diseases in population groups; and on the type and level of the healthcare in the Slovak Republic. Use Section of Health of Ministry of Health and appropriate Medical Societies use these data. Collected information on the incidence and distribution of congenital heart disease in the population result from mortality and survival of patients with that disease. (National Health Information Center)

Since 1994, in Slovakia there is mandatory reporting and registration of all birth defects. This report falls within three categories:

1) Vascular disease in live births
2) Vascular disease in stillbirths
3) Prenatally detected vascular disease, which gave rise to abortion.

In 2007, the American Heart Association (AHA) made a declaration of non-heritable risk factors for congenital cardiovascular diseases according to previously available literature and studies collected worldwide. The statement listed the factors that may influence the occurrence of CVD in the preconception period (3 months before pregnancy) and in the first trimester of pregnancy when the fetus is most susceptible to the emergence of CVD.

1) Mother’s illness, Phenylketonuria, Diabetes, Rubella, febrile illness and flu
2) Drugs in pregnancy, Antibiotics (Ampicillin, Penicillin), Antivirals/Antiretroviral, Non-steroidal anti-inflammatory drugs (Ibuprofen)
3) Abuse of mothers, Alcohol, Cocaine, Marijuana, Nicotine
4) Environmental impacts, Organic solvents (chemical plants – paints and hair sprays, paints), Herbicides, Pesticides and Rodenticides (agricultural industry), Air pollution, Contamination of groundwater (trichloroethylene)
5) Socio-demographic factors, Age of partners (women and men)

Possibilities of Prevention in Reducing Cardiovascular Disease

To reduce the incidence of cardiovascular disease can reach the knowledge and targeted prevention aimed at influencing modifiable risk factors, particularly pharmacological influenced blood pressure, lifestyle changes and increased physical activity, and psychosocial factors.

<table>
<thead>
<tr>
<th>Primary prevention</th>
<th>• protect the body from disease emergence</th>
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<tbody>
<tr>
<td></td>
<td>• population strategy</td>
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</table>

✓ Identification and reduction of major risk factors in the population
✓ identification of persons at high risk
**Secondary prevention**

- individual strategy (high-risk strategy) ✓ reduce their individual risk level
- reduce the incidence of disease in the population
- slowing/stopping disease progression
- prevention of complications
- prevention of premature death
- prevention and control of chronic diseases
- use prevention options in non-invasive diagnostics ✓ non-invasive methods in radiology – USG, CT, CMRI

**Tableno.1 Possibilities of prevention in reducing CVD**

4. **Noninvasive Imaging - Radiology**

Paradoxically, currently living in populations with more adult congenital heart disease than children themselves, the majority of these patients have complex cardiac defects and require lifelong monitoring as they occur in the form of complications of heart failure with possible pulmonary hypertension, thrombo-embolism, arrhythmias and sudden death.

4.1 **Postnatal Diagnosis**

Cardiologists use echo-cardiographic examination as part of their evaluation and since it is in the area of Cardiology, chest radiographs are currently used in long term follow-up of changes of heart and blood vessels.

4.2 **Computed Tomography**

Computer Tomography – Cardiac MSCT makes a particularly significant contribution to the diagnosis of coronary artery disease and disability has replaced angiography diagnostic imaging of coronary artery intervention. The diagnostic advantage of CT over angiographic intervention predestines prevention of ischemic complications. Early diagnosis allows appropriate treatment according to the finding of disability coronary artery. Cardio CT can also evaluate perfusion and disability of and valvular system then higher radiation exposure cardio MRI (CMRI – cardio magnetic resonance imaging) is perfected.

4.3 **Cardiac catheterization**

It reveals the anatomy of the coronary arteries; the degree of pulmonary artery constriction; pulmonary artery anatomy and the branches of the aorta; the extent of ventricular septal defect (VSD). Catheterization also should be defined for patients who are undergoing intervention (e.g. unstop of distal pulmonary artery stenosis, percutaneous valve implantation); or if the result of non-invasive tests is inconclusive. Another indication for catheterization is to determine the resistance of pulmonary vasculature.
4.4 Magnetic resonance imaging

CMRI may be an alternative for patients with TOF (Tetralogy of Fallot) conduit who have an implanted pacemaker or defibrillator, and also provides valuable information on coronary arteries, lung parenchyma and the extent of calcification.

In the last decade MRI has become a unique method of diagnosis. Its advantage lies in the complexity and nature of outpatient examinations. Cardiovascular magnetic resonance imaging has found wide application, especially due to non-invasive, accurate, comprehensive assessment of anatomy; the function of the heart without radiation which is particularly beneficial for patients with congenital heart disease who undergo repeated lifelong examinations.

**Indications Cardiovascular MRI:**

A. Congenital heart defects
   1. Preoperative diagnosis
   2. Monitoring of postoperative complications (most indications)

B. Acquired heart disease
   1. Diseases of cardiac valves and their replacements
   2. Myocardial diseases
      - Coronary (postischemic cardiomyopathy)
      - Acoronary (dilated cardiomyopathy, hypertrophic)

C. Other indications
   1. Diseases of the pericardium
   2. Tumors of the heart
   3. Diseases of the aorta and great vessels

5. Advantages and Disadvantages of CMRI

Compared to other non-invasive modalities such as ultrasound and CT, MRI has several advantages:

a) MRI examination without radiation, thus allowing retesting of children and of pregnant women, although it should not be indicated in the first 12 weeks of pregnancy.
b) A relatively high resolution 3D image of the heart and blood vessels
c) Compared to echocardiography, MRI picture is limited interference with an adjacent shell and the ambient air
d) Widespread diagnostic option compared to CT and echocardiography.

Disadvantages:

The risk of nephrogenic system fibrosis (NSF) is found only in the group of patients with kidney disease (severe acute or chronic renal insufficiency with a glomerular filtration rate < 30 ml/min./1.73 m²) with an incidence of 3-5% after administration of gadolinium contrast agent.

The length of the examination was significantly higher (30-120 minutes), as compared to CT and echocardiography.
Requires more cooperation of the patient and the fact that 2% of the population suffers from claustrophobia should not be neglected, which in certain cases completely prevents examination. In children sedation or general anesthesia are needed.

Material of various life support equipment is incompatible with MRI and the patient is isolated from direct care, therefore its use is limited in acute conditions.

Absolute contraindication are implanted pacemaker or defibrillator; aneurismal vascular clamps and electrical implants (insulin pump); unless it is writing, the accompanied document is limiting compatibility with their MRI; metallic foreign bodies from non-demonstrable non-magnetic metal. Metal implants can be broken by a strong magnetic field and may distort the resulting image. At the present time, MRI compatible aneurismal clamps, stents, vascular filters and pacemakers are being built.

Disadvantage remains well below the spatial resolution compared to CT, which limits the assessment of small structures such as coronary arteries.

<table>
<thead>
<tr>
<th>CMRI</th>
<th>CT</th>
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<tbody>
<tr>
<td>• possible view in any scan</td>
<td>o examination in the axial scan with the possibility of multiplanar reconstruction</td>
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<tr>
<td>• without radiation exposure</td>
<td>o radiation exposure +++</td>
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<td>• longer period of the breath-holding during the examination</td>
<td>o relatively short period of the breath-holding during the examination</td>
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<tr>
<td>• generally longer time to examination</td>
<td>o relative short period for examination</td>
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<td>• options for the post-processing +++</td>
<td>o options for the post-processing +++</td>
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<tr>
<td>• limited resolution 1-2 mm</td>
<td>o resolution is possible to 0,4 mm</td>
</tr>
<tr>
<td>• usefulness image without contrast medium +++</td>
<td>o limitation of meaningful images without contrast medium</td>
</tr>
<tr>
<td>• software for performance evaluation of right ventricular function</td>
<td>o is not adequate software for performance evaluation of right ventricular function</td>
</tr>
<tr>
<td>• possible to measure blood flow</td>
<td>o is not possible to measure blood flow</td>
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<tr>
<td>• viewing during the free breathing</td>
<td>o examination only with breath-holding</td>
</tr>
<tr>
<td>• local distortion of the image from metallic materials</td>
<td>o relatively minor artifacts from the metal</td>
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<tr>
<td>• poor visualization of calcium</td>
<td>o well visible calcium</td>
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<td>• limitation imaging coronary artery</td>
<td>o properly imaging coronary artery</td>
</tr>
<tr>
<td>• very low percentage allergy reaction to contrast media</td>
<td>o relatively high percentage allergy reaction to contrast media</td>
</tr>
<tr>
<td>• small number of Departments</td>
<td>o sufficient number of Departments</td>
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</tbody>
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Table no. 2 The advantages and disadvantages between CMRI and CT Compared

Cardiovascular Magnetic Resonance Imaging (CMRI)

It is used in preoperative diagnosis of conditions rather exceptionally, mostly only in inconclusive findings, however, becoming increasingly important especially in the post-operative diagnosis of late complications in adults with congenital heart defects and where echocardiography results are borderline or ambiguous.

In terms of long-term management are critically important data on volumes and ejection fractions chambers and severity of valvular regurgitation are critically important.

CONCLUSION

In 2010, the European Society of Cardiology (ESC) published a document which lists indications, when the diagnosis by CMR preference to echocardiography in adult patients with congenital heart disease is used:

- a) Quantification of right ventricular volumes and ejection fraction of the right
- b) Quantification of valvular regurgitation pulmonary artery,
- c) Evaluation of the pulmonary arteries (stenosis, aneurism) and the aorta (aneurism, dissection, coarctation),
- d) Assessment of systemic and pulmonary veins (anomalous connection obstruction),
- e) Detection of collateral and arterio-venous malformations (CT is preferable),
- f) Diagnosis of coronary artery anomalies (CT is preferable),
- g) Assessment of intra- and extra-cardiac tumors (CT is preferable),
- h) Quantification of myocardial mass of the right and left ventricle,
- i) Defection and quantification of myocardial fibrosis or scarring,
- j) Assessment of the nature of tissue (fibrosis, fat, iron deposits).

Efficiency in the use of the MRI evaluation:

- Complex anatomy of the heart
- Cardiac function
- Myocardial viability and perfusion
- Valvular disease and pericardial disease
- Intracardiac tumors
- Congenital heart defects and postoperative complications

CT is primarily used for efficiency assessing coronary arteries. The use of MRI for cardiac diagnosis particularly needs the use of a paramagnetic contrast agent.

By its application, it is possible to detect and characterize intracardiac masses, thrombi, myocarditis and specific processes such as sarcoidosis.

Post-contrast examinations and evaluation bring advantages in many aspects, and according to the character of diagnosing, it is divided into the perfusions examination, late enhancement and angiography.
Radiological imaging methods significantly contribute to the diagnosis and prevention of cardiovascular diseases. Significant increase in cardiovascular CT and CMRI high standard hardware and software requires an increase in the educational process of Radiographers and Radiologists.

**BIBLIOGRAPHY**


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