UDC 616-003.218-008.817-056.7-053.2-037

DATA PROCESSING AND ANALYSIS PROBLEMS IN CLINICAL RESEARCH

V. A. Klymenko[1], N. M. Drobova[1], O. V. Piontkovska[2], T. O. Khalturina[2], O. V. Pasichnyk[2], S. S. Shelest[2], O. V. Vysotska[3], A. I. Pecherska[3]

[1] Kharkiv National Medical University,

[2] Municipal Nonprofit Enterprise «Regional Children's Clinical Hospital № 1» of the Kharkiv Regional Council

[3]National Aerospace University «Kharkiv Aviation Institute»

Cystic fibrosis (CF) is a genetic disorder with lesions of the exocrine glands of vital organs and systems. Bronchopulmonary and liver lesions are ranked the first places in the death causes list in patients with CF. Mathematical models creation for objectification of the bronchiectasis and liver cirrhosis development prediction in children with CF should improve the quality and life expectancy of these patients.

Introduction. Cystic fibrosis (CF) is a genetic disorder with lesions of the exocrine glands of vital organs and systems. Bronchopulmonary and liver lesions are ranked the first places in the death causes list in patients with CF. Mathematical models creation for objectification of the bronchiectasis and liver cirrhosis development prediction in children with CF should improve the quality and life expectancy of these patients. Only an integrated approach is the key to a successful solution in any life area in today's world. Prophylaxis and prevention of serious diseases is the main goal of modern medicine and society as a whole. First of all, genetic diseases with a constantly progressing course require a careful approach to calculating the probability of irreversible pathological changes. A striking example is CF (a genetic disease with an autosomal recessive type of inheritance, which is caused by a mutation in the gene of the transmembrane regulator of CF with damage to the exocrine glands of vital organs and systems) [1-5]. Fibrotic changes prevention, especially in the lungs, liver and pancreas is the main medical goal and a positive prognosis for life expectancy of patients in this category. The mathematical approach with the maximum accuracy provides calculation of pathological condition probability, gives the chance to correct a necessary part of the disease pathogenesis in time. Therefore, the cooperation of scientists in the medical and technical fields provides a comprehensive approach to solving clinical problems.

Purpose. To improve medical care for patients with CF by treatment individualization according to the prediction of the respiratory and liver complications development.

Task. To create a mathematical models for predicting of the bronchiectasis and liver cirrhosis development in children with CF.

Materials and methods. Department of Propaedeutic of Pediatrics No 2 of Kharkiv National Medical University cooperates with the Department of Computer Radioelectronics and Biomedical Technologies of National Aerospace University "Kharkiv Aviation Institute on the topic of CF in children since 2015. Two mathematical models were created to predict the development of liver cirrhosis and bronchiectasis in children with CF due to this cooperation. The research was conducted in the Pulmonology department of the Municipal Nonprofit Enterprise "Regional Children's Clinical Hospital № 1" of the Kharkiv Regional Council. Clinical and paraclinical examinations of patient with CF were carried out according to the Order of Ministry of Healthcare of Ukraine of July,15 2016 No 723 and of January, 29 2013 No 59 “On approval of unified clinical protocols of medical care for children with diseases of the digestive system”. Mathematical processing of the results was carried out using the SPSS 23 package for Windows. The study was conducted with respect to human rights in accordance with the legislation in force in Ukraine, in compliance with international ethical requirements and didn’t violate ethical norms in science and standards for conducting biomedical research.

Results. Forty-two children were examined. Diagnosis of CF was based on clinical and paraclinical characteristics and confirmed by the results of pilocarpine test. The analysis of 112 clinical and paraclinical signs was conducted (age, complaints, anamnesis of disease and life, the laboratory and instrumental research results like as blood test, urinalysis, coprogram, spirogram, electrocardiography, computed tomography of the chest, ultrasound examination of the abdominal cavity, bacteriological examination of sputum, bronchial lavage fluid, immunological parameters, allergy testing data, etc.). All signs were coded and assigned to a 112-dimensional vector that takes into account the absence, presence, direction, and magnitude of each sign.

The logistic regression equation for the prediction of bronchiectasis development at children with CF was created:

$$P = [1+\exp(-(0{,}316\times X_1+0{,}083\times X_2+4{,}009\times X_3+6{,}778\times X_4-43{,}372))]^{-1},$$

where P – the risk factor for the bronchiectasis development in a child with CF;

X_1 – phagocytosis of latex (%);

X_2 – sweat chloride level (mmol/l);

X_3 – evaluation of liver parenchyma according to ultrasound examination (1- norm, 2 - increased liver echodensity at ultrasound examination, 3 – cirrhotic lesions of the liver parenchyma;

X_4 – S. aureus (in sputum) (1 – no, 2 - yes).

The P value is in the range from 0 to 1 and reflects the probability of the risk of bronchiectasis formation in a child with CF. If $P \geq 0.5$, it predicts a high risk of bronchiectasis formation, and if $P < 0.5$, it predicts a low risk of bronchiectasis formation.

The mathematical model testing for patients with CF from the Dnipro Region was carried out. Efficiency was 86.7 %.

The logistic regression equation, which determines the probability of developing liver cirrhosis in children with CF has following form:

$$P= [1+\exp(-(2{,}371\times X1+0{,}408\times X2-0{,}810\times X3+3{,}861\times X4-3{,}215\times X5-0{,}558))]^{-1},$$

where P – the risk factor for the liver cirrhosis development in a child with CF;

X1 – digestive system pathology (1 – no, 2 - yes);

X2 – CD3 (%);

X3 – CD4 (%);

X4 – bronchiectasis (1 – no, 2 - yes);

X5 – S. aureus (in sputum) (1 – no, 2 - yes).

The P value is in the range from 0 to 1 and reflects the probability of the risk of liver cirrhosis formation in a child with CF. If $P \geq 0.5$, it predicts a high risk of liver cirrhosis formation, and if $P < 0.5$, it predicts a low risk of liver cirrhosis formation.

The mathematical model testing for patients with CF from the Dnipro Region was carried out. Efficiency was 93.4 %.

Conclusion. Treatment algorithms personalization provides high positive results of the disease prognosis. Creating mathematical models to calculate the probability of the pathological condition developing allows to adjust the treatment algorithm of the patient in time.

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UDC 621.372.413

PLASMONIC METAMATERIALS WITH A LARGE GROUP DELAY TIME IN MICROWAVE REGION

Y. N. Savin

O. Ya. Usikov Institute for Radiophysics and Electronics of National Academy of Sciences of Ukraine,
12 Ac. Proskura St., Kharkiv, 61085, Ukraine

E-mail: yuriy-n-s@i.ua

The paper is devoted to the study of plasmon induced transparency (PIT) and slow light effects in the new constructed plasmonic metamaterial. By the numerical modelling of finite difference time domain (FDTD) method it is demonstrated the dual mode PIT effect on the fundamental lattice mode can take place