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Prognostic Model Of Formation Of Bronchopulmonary Dysplasia In Premature Babies.

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ABSTRACT

Bronchopulmonary dysplasia (BPD) is a typical disease for premature infants, developing on mechanical ventilation and / or inhalation oxygen therapy, primarily in very premature babies.This paper shows the development of a mathematical model based on: history of miscarriages, threatened miscarriage, polyhydramnios, SARS during pregnancy, family history (bronchial asthma, allergy), male, low Apgar score, gestational age <32 weeks, functional PDA, low birth weight (<1500 g). The developed mathematical models were tested in Department of Neonatal and Premature, and showed high accuracy in determining a high risk of developing BPD.

Keywords: bronchopulmonary dysplasia, premature, diagnostic features, mathematical model

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INTRODUTION

Over the past decades, in the Russian Federation, as well as throughout the world, there has been an increase in the number of preterm births with a tendency to a decrease in the gestational age of children at birth. In the context of the expanding possibilities of modern medicine, the improvement of intensive care methods and respiratory support for newborns, there is an increase in the survival rate of premature babies with very low body mass. Along with this, the problem of the formation of chronic lung disease patients in this group has acquired particular urgency.

According to official statistics, respiratory diseases currently occupy a leading position in the structure of the overall morbidity of children and adolescents, significantly affecting infant mortality rates.

Bronchopulmonary dysplasia (BPD) is a typical disease for premature infants, developing on mechanical ventilation and / or inhalation oxygen therapy, primarily in very premature babies.

Over the past 20 years, the progress made in perinatology and neonatal intensive care has greatly influenced the manifestations and outcomes of BPD. However, at present this pathology has high morbidity and mortality, especially in the group of premature newborns with a birth weight of <1000 g.

The development of BPD is combined with adverse long-term outcomes both to the respiratory and nervous system, and to increased mortality in children with very low and extremely low body weight. Predicting the likely negative consequences and the timely diagnosis of this disease is the most important goal of providing inpatient and outpatient care to premature babies at risk of developing BPD.

To improve the decision-making system in healthcare, both at the level of the attending physician and at the level of the healthcare management, it is important to use models, algorithms and mathematical methods built on the basis of expert knowledge using large volumes of archival and operational information.

MATERIALS AND METHODS

During the study, matrix of development of bronchopulmonary dysplasia was formed in premature infants with EBMT and LMB with a gestation period of less than 32 weeks (Table 1).

Matrix X = (X1, X2, X3)
Where
X1 = (X11, X12, X13)
X2 = (X21, X22, X23)
X3 = (X31, X32, X33)

Table 1: Expert estimates and weights

variable.	INDICATORS	ASSESSMENT OF EXPERTS								∑	w_i
X_1											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**		
X_{11}	History of miscarriages	5	6	7	6	8	9	8	8	57	0,28(3)
X_{12}	Threatened miscarriage	6	7	6	6	5	8	6	6	50	-0,1(6)
X_{13}	Poly hydramnios	9	9	10	10	9	10	9	9	75	-0,58(3)
X_{14}	SARS during pregnancy	8	7	9	9	9	10	9	10	71	-0,51(6)
X_{15}	Family history (bronchial asthma, allergy)	8	9	9	9	9	9	9	10	74	-0,5(6)
X_2											
X_{21}	Male	8	9	10	9	8	7	10	9	60	0,(3)
X_{22}	Low Apgar score	4	3	2	4	3	4	5	4	23	-0,28(3)

X_{23}	gestationalage<32 weeks	1	1	2	1	2	1	1	1	10	0,5
X_{24}	functional PDA	7	6	7	8	7	9	6	6	48	-0,1(3)
X_{25}	Low birth weight (<1500 g)	2	1	3	1	2	2	2	2	15	0,41(6)
X_3											
X_{31}	Lack of RDS prevention	1	1	1	1	1	2	2	2	11	0,48(3)
X_{32}	IVL> 6 days	1	1	1	2	3	2	2	3	15	0,41(6)
X_{33}	Congenital and post natalinfection	8	6	7	5	4	6	6	6	48	-0,1(3)
X_{34}	heavy VLS	6	7	3	4	5	5	4	5	39	0,01(6)
X_{35}	Post natalhy potrophy	4	6	8	8	7	7	7	8	55	-0,25

The study was conducted in several stages. At the first stage, for each indicator, all its possible values are ranked by degree of significance. For the ranking of each value, an a priori ranking method is used that uses expert information. This method allows you to objectively assess the subjective opinion of specialists (experts), since with a large number of parameters, expert opinion on the degree of influence of a particular factor may differ.

When collecting a priori information, experts (m> 7) are asked to fill in questionnaires in which it is necessary to evaluate the values of the indicator depending on the degree of their influence on the likelihood of a recurrent stroke.

As a result of ranking indicators by the degree of decreasing or increasing their influence, a certain rank is assigned to each linguistic value. If experts find it difficult to assign different ranks to all values, they can assign the same ranks to two or more variables. In the case of identical ranks, the ranking matrix is reduced to a normal form. For this, variables with the same ranks are assigned a rank equal to the average value of the places that the variables have divided among themselves.

According to the ranking matrix, an assessment is made of the consistency of experts using the concordance coefficient:

$$W = \frac{S\left(d^2\right)}{\frac{1}{12}m^2(n^3-1) - m\sum_{j=1}^{m} T_j}, \qquad (1)$$

where$S(d)^2$is the sum of squared differences

$$d = \left(\sum_{j=1}^{m} a_{ji}\right) - \frac{1}{2}m(n+1); \qquad (2)$$

a_{ji} – generalized sum of ranks of j-th variable; T_j – value determined by formula

$$T_j = \frac{1}{12}\sum_{i=1}^{n}(t_j^3 - t_j); \qquad (3)$$

t_j- is the number of repetitions of the i-th rank in the j-th row of the matrix. If the ranking matrix does not contain matched ranks, then

$$W = \frac{12S(d^2)}{m^2(n^3-1)}. \qquad (4)$$

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The value of the concordance coefficient lies within (0 ... 1). With W = 1, experts are unanimous in assessing the significance of each linguistic value of an indicator, with W = 0, there is no agreement.

The assessment of the significance of the coefficient of concordance W is made by the χ^2 – Pearson criterion:

$$\chi^2_{pac} = m(n-1)W. \qquad (5)$$

If, with the number of degrees of freedom f = n-1, the critical value turns out to be less than the calculated one, then the hypothesis about the availability of expert consent is accepted.

The model itself is presented in the form of convolution:

$$Y = \sum w_i x_i \qquad (6)$$

where

$$w_i = \frac{m \cdot n - \sum_{j=1}^{m} r_{ij}}{n \cdot m \cdot \left(n - \frac{m-1}{2} \right)}, \; i = \overline{1,n} \qquad (7)$$

r_{ij} – is the assessment of the j-th expert, n - is the number of parameters, m - is the number of experts, x_i - is the score of the indicator.

The values of all indicators are translated into numerical estimates, which are normalized, as a result, receive normalized estimates, which are substituted into the resulting model.

RESULTS AND DISCUSSION

The model of formation of BPDs taking into account maternal risk factors will look as follows:

Y_1=[-0,28(3)*x_{11}-0,1(6)*x_{12}-0,58(3)*x_{13}-0,51(6)*x_{14}-0,5(6)*x_{15}]

Where

X_{11}–history of miscarriages
X_{12} – threatened miscarriage
X_{13} – polyhydramnios
X_{14} – SARS during pregnancy
X_{15} -family history
(bronchial asthma, allergies)

The values of the developed model lie in the interval Y1ϵ [0..2].
The first model for predicting the development of BPD, taking into

account neonatal risk factors, is as follows:

Y2 = [- 0, (3) * x21-0.28 (3) * x22 + 0.5 * x23-0.1 (3) * x24 + 0.41 (6) * x25]

where
X_{21} – male
X_{22} – low Apgar score
X_{23}–gestational age <32 weeks

X_{24} – functional PDA
X_{25}– low birth weight (<1500 g)

The values of the developed model lie in the interval Y2ϵ [0..1,6].

The first model for predicting the development of BPD, taking into account neonatal risk factors, is as follows:

Y3 = [- 0.48 (3)] * x31 + [- 0.1 (3)] * x32 + 0.01 (6) * x33 + 0.01 (6) * x34 + 0.25 * x35

Where

X_{31} – lack of RDS prevention
X_{32} – mechanical ventilation> 6 days
X_{33}– congenital and postnatal infection
X_{34}– heavy VLS
X_{35} - postnatal hypotrophy

The values of the developed model lie in the interval Y3ϵ [0..0,9].

As noted above, the values of the developed BPD formation model, taking into account maternal risk factors, are within 0..2.

The model of formation of BPD, taking into account maternal risk factors, is estimated by the values of the obtained model by substituting the scores as follows (Table 2).

Table 2: Risk levels of BPD in premature babies

The risk level of BPD	High	Middle	Low
Y_1	1,2 – 2	0,4-1,2	0-0,4
Y_2	1,0 – 1,6	0,2-1,0	0-0,2
Y_3	0,6 – 0,9	0,3-0,6	0-0,3

RESULTS

The developed models for identifying the risk of developing bronchopulmonary dysplasia in premature newborns with a gestation period of less than 32 weeks were tested in the Department of Neonatal and Premature of VODKB No. 1. The models showed their clinical efficacy.

The results confirm the modern concept of the multifactorial nature of bronchopulmonary dysplasia in preterm infants. Diagnostic tables from this study are useful for the early detection of patients who have a high risk of developing BPD for timely therapeutic measures, which will prevent serious complications in the future.

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