Development of a control and measuring method for assessing the state of patients with «HIV + tuberculosis» coinfection

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Abstract. The scientific research presents a control and measuring method for assessing the condition of patients with HIV-associated tuberculosis. The methodology was developed using a point-based method for assessing indicators. The studied parameters were grouped into 4 clusters (anamnestic data, comorbid diseases, clinical data, laboratory studies). The metrological support of anamnestic data and clinical data was considered in particular detail. The approbation of the technique was carried out on patients who are kept in institutions of the penal system. The applicability has been proven using the methods of systems analysis (correlation, regression and analysis of variance data).

Today, tuberculosis is one of the leading causes of death in HIV-positive patients. For modern medicine, the problem of coinfection "HIV + tuberculosis" is of great relevance, therefore, scientific research is being actively carried out in this area [1-4]. In addition, the development of predictive models is of particular interest [5, 6]. There are a number of disadvantages to the ongoing scientific research. For example, in scientific studies [1-3], a connection was revealed between the transition of HIV to AIDS and the stages of concomitant tuberculosis, but the proposed prognosis methods do not take into account all the patient's indicators.

The number of dangerous tuberculosis patients with HIV infection in prisons is much higher in comparison with civil health care institutions. In the conditions of detention and serving of sentences, tuberculosis infection and HIV accelerate and aggravate the course of the disease. In addition, a complex of specific penitentiary factors (e.g. lack of fresh air and sunlight, physical inactivity, penitentiary stress, etc.) effects prisoners' health. As a result, a special course of «tuberculosis+HIV» co-infection is formed, and it causes an increased risk of rapid death.

The course of tuberculosis in patients is characterized by a wide range of diverse clinical and radiological manifestations. Tuberculosis is the leading HIV-associated disease among prison patients and is the leading cause of death in HIV-infected patients. That is why the development of control and measurement methods and metrological support for assessing the condition of patients with HIV + tuberculosis co-infection was carried out on the example of penitentiary institutions. It should be noted that the developed technique is also applicable under normal conditions.

All of the above leads to the need of changing the approach of the treatment and development of the disease prognosis [7]. In connection with the above, the issues of determining the severity of tuberculosis in combination with HIV infection are of considerable interest.
The aim of the research is to create a new system for assessing the condition of a patient with HIV + tuberculosis coinfec-
tion with the possibility of using it in the penitentiary system.

To solve this problem, 4 groups of indicators (clusters) were identified, characterizing different aspects of the patient's condition.

A scoring system was developed for each indicator. As a result of the summation of points in each cluster, the weight of the cluster and its contribution to the total amount of points were determined, by which the severity of the disease was assessed. Thus, a new approach to the comprehensive assessment of the patient's condition with «tuberculosis+HIV» coinfection was proposed.

In the first cluster, data from the anamnesis were presented (table 1). In particular, the following factors were taken into account: the duration of the patient's use of injecting drugs, the duration of HIV infection and tuberculosis, the presence of excretion of Microbacterium tuberculosis, the duration of the disease with viral hepatitis B and C, the presence of mixed infection (viral hepatitis B + viral hepatitis C), and chronic alcoholism.

| parameter                                             | status | points |
|-------------------------------------------------------|--------|--------|
| Duration of injecting drug use (years)                | No     | 0      |
|                                                      | <1     | 1      |
|                                                      | 1-2    | 2      |
|                                                      | ≥2     | 3      |
| Duration of HIV infection (years)                     | ≤1     | 1      |
|                                                      | 1-2    | 2      |
|                                                      | ≥2     | 3      |
| Duration of tuberculosis (years)                      | No     | 0      |
|                                                      | ≤1     | 1      |
|                                                      | 1-2    | 2      |
|                                                      | ≥2     | 3      |
| Mycobacterium tuberculosis expectoration (score)      | No     | 0      |
|                                                      | Yes    | 3      |
| Duration of viral hepatitis B (years)                 | No     | 0      |
|                                                      | ≤1     | 1      |
|                                                      | 1-2    | 2      |
|                                                      | ≥2     | 3      |
| Duration of viral hepatitis C (years)                 | No     | 0      |
|                                                      | ≤1     | 1      |
|                                                      | 1-2    | 2      |
|                                                      | ≥2     | 3      |
| mixed infection (viral hepatitis B + viral hepatitis C)| No     | 0      |
|                                                      | Yes    | 3      |
| The presence of chronic alcoholism (score)            | No     | 0      |
|                                                      | Yes    | 3      |

The second group of factors was devoted to the scoring of clinical indicators (table 2). Indicators such as respiratory rate, body temperature, systolic blood pressure, heart rate, body mass index, change in consciousness were recorded.
Table 2. Application of the scoring control and measurement technique for clinical indicators.

| parameter                                     | status | points |
|-----------------------------------------------|--------|--------|
| Number of breaths per minute                  | ⩽8     | 3      |
|                                               | 9-11   | 1      |
|                                               | 12-20  | 0      |
|                                               | 21-24  | 2      |
|                                               | ⩾25    | 3      |
| Body temperature (°C)                         | ⩽35.0  | 3      |
|                                               | 35.1-36.0 | 1    |
|                                               | 36.1-37.0 | 0    |
|                                               | 37.1-38.0 | 1    |
|                                               | ⩾38.1  | 2      |
| Systolic blood pressure (mm Hg)               | ⩽90    | 3      |
|                                               | 91-100  | 2      |
|                                               | 101-110 | 1      |
|                                               | 111-130 | 0      |
|                                               | 131-150 | 1      |
|                                               | 151-170 | 2      |
|                                               | ⩾171   | 3      |
| Heart rate in 1 minute                        | ⩽40    | 3      |
|                                               | 41-50   | 1      |
|                                               | 51-90   | 0      |
|                                               | 91-110  | 1      |
|                                               | 111-130 | 2      |
|                                               | ⩾131   | 3      |
| Body mass index BMI m²/kg                     | ⩽16.0  | 3      |
|                                               | 16.1-17.0 | 2    |
|                                               | 17.1-18.0 | 1    |
|                                               | 18.1-25.0 | 0    |
|                                               | 25.1-30.0 | 1    |
|                                               | 30.1-40.0 | 2    |
|                                               | ⩾40.1  | 3      |
| Change in consciousness                      | No     | 0      |
|                                               | Yes    | 3      |

The third and fourth clusters were also identified. The third cluster concern comorbid diseases. The conditions and diseases such as nephropathy, cardiomyopathy, arthralgia and myalgia, lymphadenopathy, hepatosplenomegaly, HIV encephalopathy, chronic bacterial infections, herpes infection, mycoses were considered. In the fourth cluster, information about laboratory studies was collected. The content of leukocytes, platelets and erythrocytes in the patient's blood, erythrocyte sedimentation rate, hemoglobin level, total protein content, transaminase level, viral load, CD 4 level were analyzed.

To assess the effectiveness of the proposed system for assessing the patient's condition, 36 people were examined. We used: correlation, regression and variance analyzes [8-11]. When conducting
correlation analysis, a fairly high correlation was noted between the outcome of the disease and the sum of points in each cluster separately (table 3).

**Table 3.** Indicators of the correlation coefficient between the considered clusters and the outcome of the disease.

| Cluster number | Cluster 1. Anamnestic indicators | Cluster 2. Clinical indicators | Cluster 3. Comorbid diseases | Cluster 4. Laboratory indicators | Sum of points for four clusters |
|----------------|----------------------------------|-------------------------------|-----------------------------|---------------------------------|---------------------------------|
| Correlation coefficient | 0.64 | 0.82 | 0.68 | 0.61 | 0.70 |

When conducting regression analysis [11], an equation was obtained that establishes the relationship between the outcome of the disease and the points sum of the four considered clusters. The correctness of the proposed formula was also calculated, which turned out to be 86.1% (5 erroneous predictions out of 36 observations). For a lethal outcome, the prediction correctness was 75% (three out of four fatal outcomes were predicted correctly), for a patient's deterioration, the prediction correctness was 72.7% (a prediction was given for eight out of eleven cases of patient deterioration during a year of observation), for the phenomenon remission - 90.4% (the system calculated the correct prognosis for 19 out of 21 remission cases). Thus, a control and measurement methodology and metrological support for assessing the condition of patients with HIV-associated tuberculosis were created. The studied indicators were grouped into 4 clusters (anamnestic indicators, comorbid indicators, clinical indicators, laboratory tests). The technique was tested on 36 patients. The possibility of applying the above technique has been proven using the methods of systems analysis and mathematical statistics.

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