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THE STATISTICAL MODULE FOR THE SYSTEM OF ELECTRONIC REGISTRATION OF INFORMATION ABOUT PATIENTS TREATED FOR INFERTILITY USING THE IVF ICSI/ET METHOD

Abstract: Infertility treatment using IVF methods requires to the collection, storage and analysis of large quantities of various types of data. Created at the University Hospital in Bialystok, system of electronic registration of information about patients treated for infertility using the IVF ICSI/ET method, turned out to be useful in the process of data collection and storage of information about treated couples. However, it does not satisfy the condition relating to the need to analyze the data collected. For this reason, system developers have taken the trouble of improving it with a statistical module that fulfills hopes connected with it. This module consists of two main parts which generally may be called: descriptive statistics and neural network. The first part of the module refers to the designation and presentation of descriptive statistics. They are based on a number of key features of the treatment process, as well as the juxtaposing the designated statistics, broken down into groups defined by the grouping variables. The second part concerns the neural network to predict the efficacy of the treatment. The network which has been used here provides nearly 90% probability treatment failure and can be used for the prediction of negative cases.

Introduction

The infertility treatment is a process that requires the collection, and above all, the analysis of large quantities of specific data. The concept of a hospital information system is well known in medical computer sciences [1], but existing popular software on the medical application market is not designed to collect specialized data. The majority of such applications collect

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the most common data, mainly concerning personal information, course of treatment, findings, procedures performed, diagnosis, therapy, medical education and hospital administration [2]. In many cases, they cover the demand of medical units, mainly due to administrative needs and requirements imposed by the National Health Fund [3]. However, due to ever-changing medical procedures, one should not count on the market to find a dedicated medical software application that will be ready to collect data essential to our field. For this reason, specialized systems have been created to handle data related to the narrow scope of medical activities, most often a specific clinic or department.

The system of registration information about patients treated with the IVF ICSI/ET method

One of the specialized applications related to a narrow scope of medical activities is an electronic system for recording information on patients treated for infertility using the IVF ICSI/ET method implemented in the Department of Reproduction and Gynecological Endocrinology of the University Hospital in Bialystok [4]. One of the main tasks of the clinic's activities is to treat couples affected by infertility problem. A number of complex procedures are carried out here, among which many procedures are associated with the process of in vitro fertilization (IVF) combined with intracytoplasmic sperm injection (ICSI), and then with the transfer of obtained embryo (ET) to the uterus [5]. This process involves the storage of vast amounts of information which if recorded on paper is difficult for statistical analysis. Such analysis is essential in maintaining a high efficacy of treatment.

The created application is the result of a collaboration between staff engaged in the treatment of infertility and those involved in programming. It is the result of many years of detailed consultation and cooperation allowing the whole group to fully understand the issue, both from the medical aspect as well as from the development environment in which the application has been made.

The application has been made in programming environment Delphi 2007 [6, 7], while the database in Microsoft Access [8] from Microsoft Office 2003 packet.

The application created in the first stage of the project, and described in [4], has allowed for collecting and managing large amounts of detailed data on infertility treatment. However, it was not equipped with automatic

statistical tools which is necessary to control and maintain an appropriate level of treatment efficacy. Therefore it was necessary to carry out the second phase of the project which should complete the system by the statistical module.

The statistical module of the system for registering information about patients treated with the IVF ICSI/ET method

This module consists of two main parts which generally can be called: descriptive statistics and neural network.

The first part of the module refers to the designation and presentation of descriptive statistics based on a number of key features of the treatment process. It also includes the juxtaposing the designated statistics, broken down into groups defined by the grouping variables. Presented in graphic form, the information concerns the following characteristics – the dependent variables (Fig. 1):

- the number of cumulus oophorus,
- the number of correct cumulus oophorus,
- the number of atretic cumulus oophorus,
- the number of luteinizing cumulus oophorus,
- the number of MII oocytes,
- the number of MI oocytes,
- the number of GV oocytes,
- the number of atretic oocytes,
- the number of 1PN, 2PN and 3PN embryos,
- the number of 2-blastomere embryos,
- the number of degenerating embryos,
- the number of embryos (class A, B, C, D) in the second day of culture,
- the number of embryos (class A, B, C, D) in the third day of culture,
- the effectiveness of treatment (getting pregnant).

Among the grouping variables which allow for the compilation of statistics into two or more groups were (Fig. 1):

- presence (or absence) of individual causes of infertility (ovulation disorders, fallopian factor, endometriosis, PCOS, male factor, idiopathic cause, the other cause),
- the selected type of treatment protocol [4],
- the number of the cycle of treatment for a given pair,
- the results of sperm analysis,
- the year of the treatment.

Fig. 1. Dependent variables and grouping variables included in the statistical module of the system

Presented in Fig. 1 additional options, allow the selection of the presented: measure of location and measure of dispersion. It is possible to choose the arithmetic mean and standard deviation, typically used for normal distributions (or at least symmetrical), and medians and quartiles, usually chosen when the distribution is not normal (and certainly when it is not symmetrical). There is also the possibility of exclusion from the presentation of extreme values, and usage of a logarithmic scale instead of a standard scale.

The graph showing the arithmetic mean and standard deviation for the number of embryos of class B in the second day of culture, presented in two groups, designated due to the presence of polycystic ovary syndrome as a cause of infertility, is shown in Fig. 2.

The largest marks (green rectangles) show the average level in each group and the smaller (red rectangles) point the standard deviation, set aside for both sides than the average. Because the option "extreme values" is selected, there are also the smallest rectangles, which indicate the minimum and maximum values in each group. The graph allows to make a visual assessment of whether the occurrence of PCOS affects the number of embryos class B in the second day of culture. Of course, there is also the option of an enhanced program to automatically perform the appropriate statistical tests that would give the answer whether there are statistically significant differences in the level of the dependent feature between the groups designated because of the grouping features. However, in the current version, the system is limited only to the graphic presentation of results.

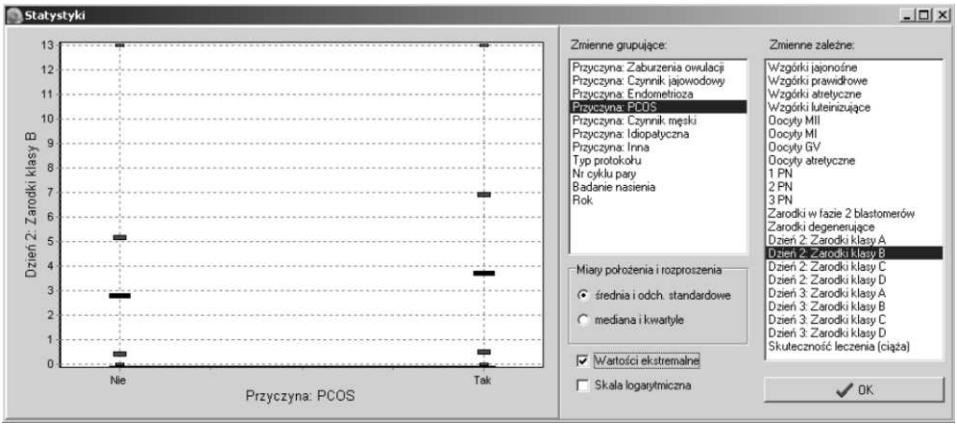

Fig. 2. The arithmetic mean and standard deviation for the number of embryos of class B in the second day of culture

Analogous graphs, except that for measurement: median and quartiles, are shown in Fig. 3.

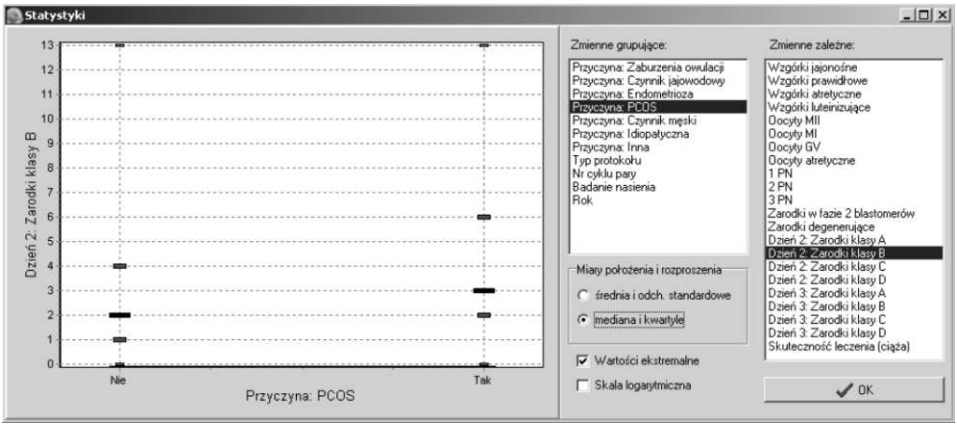

Fig. 3. Median and quartiles for the number of embryos class B in the second day of culture

A similar situation, but after excluding extreme values – minimum and maximum (unselecting the option) is shown in Fig. 4. Of course the scale of the presented graphs is adapted to the smallest and largest values of both analyzed groups.

Most of the presented characteristics are shown by charts, presenting their location and dispersion measures, possibly including the extremes (the

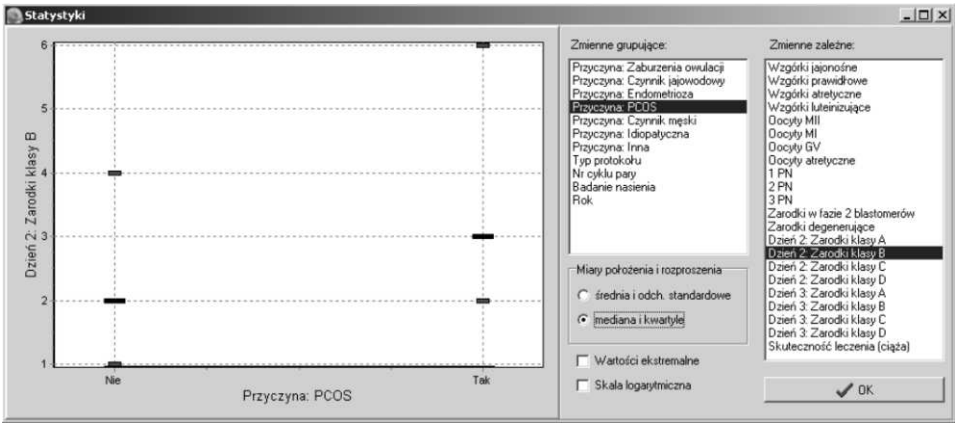

Fig. 4. Median and quartiles without extreme values for the number of embryos class B in the second day of culture

equivalent of the classical box-whiskers plot). However, there is one (but probably the most important) feature, which is presented using a bar chart. This feature means the effectiveness of medical treatment, that is the percentage of pregnancy (Fig. 5).

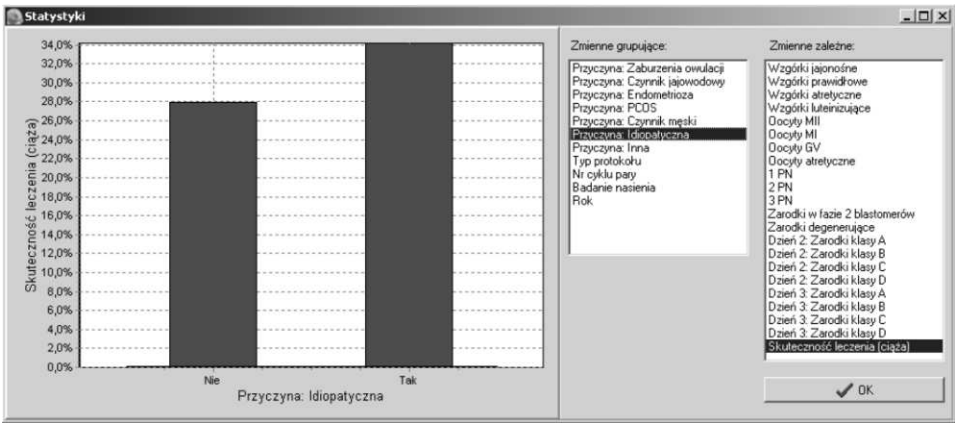

Fig. 5. Efficacy of treatment in groups designated due to the occurrence of idiopathic infertility

The graph shows a clear difference in efficacy of treatment between the two groups. In the group of patients with an idiopathic infertility, the treatment efficacy is higher (about 34%), while in the second group, it reaches 28%.

The neural network to predict efficacy of treatment

The second part of the statistical module concerns the neural network to predict efficacy of treatment. In the paper [9], authors described the trained neural network which with a probability of nearly 90% predicts failure of treatment using the IVF ICSI/ET method and can be used for prediction of negative cases. This neural network was implemented to the system for collecting information about the treatment. The outcome of the calculation is presented graphically. Colored rectangle shows the probability of the success of treatment for the couple, based on the prediction made by the trained neural network. The cut-off level is marked, which is the border between the positive and negative prediction.

Fig. 6 shows a case in which the rate of prediction is strongly shifted to the right, which theoretically predicts the success of the treatment. However, the trained network is not suitable for accurate prediction of positive cases, but only the negative. In this case the optimism of the treated couple can increase only the fact, that the rate did not hit the left edge of the rectangle, which would very likely conclude that the treatment in this cycle will fail.

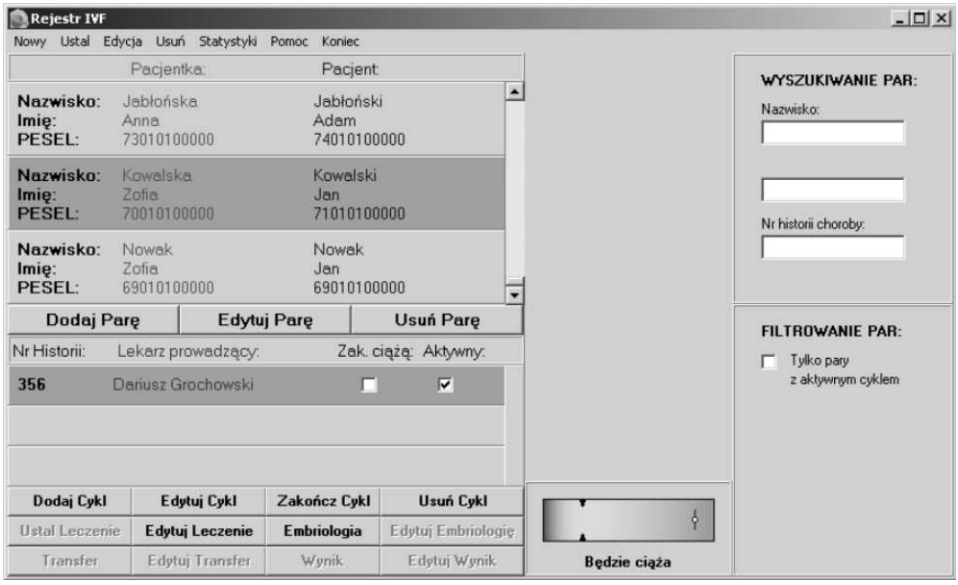

Fig. 6. The neural network forecast on the success of infertility treatment

A situation in which the prognosis of the network is not optimistic, is presented for another couple (Fig. 7).

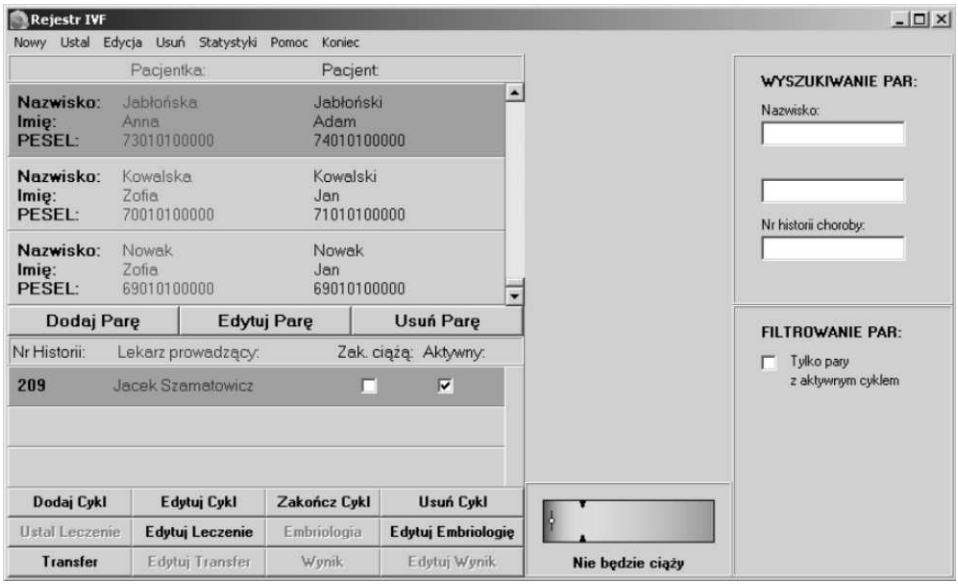

Fig. 7. The negative prognosis of the neural network, concerning the success of infertility treatment

Conclusions

The system of collecting information about treated patients after reaching the stage of stability and testing by the staff not involved in the process of programming, has been implemented for use in the Department of Reproduction and Gynecological Endocrinology in the Medical University of Bialystok. Until now data for more than a thousand pairs being treated for infertility using the IVF ICSI/ET method has been collected. However, the statistical module of the system is just being introduced in that clinic.

One of the first observed effects of applying the described above system was the improvement of the accuracy and reliability of input data [4]. This was mainly caused by forcing the need to fill some key fields of applications, which was a response to the frequently encountered lack of data. It is hoped that the dissemination of the statistical module will increase the awareness of physicians about the effectiveness of their choices made, which should result in a further increase of efficacy of the treatment. Both, graphically descriptive statistics and implemented neural network play an important role here to recognize the negative cases.

Tasks for the future

The created system with the statistical module has been implemented for use, but it means the completion of the second (not final) stage of the planned work.

The third stage of the application development will be to adapt it to network working, with the possibility of multi-user access data. Currently, the database is built on a single, selected computer. After adjusting it to network working, many users from different locations might also add, edit, and analyze patient data. This step involves not only ensuring a stable multi-user access to the data, but also the security of information collected.

After completion of the third stage of work, the application will be a major and comprehensive system, that could be adopted as a standard for the collection of information in units dealing with infertility treatment using IVF methods.

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