Milewski Robert
Medical University of Bialystok

Jamiołkowski Jacek
Medical University of Bialystok

Milewska Anna Justyna
Medical University of Bialystok

Domitrz Jan
Medical University of Bialystok

Wołczyński Sławomir
Medical University of Bialystok

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

Abstract: Infertility treatment with IVF (in vitro fertilization) methods require collection, storage and analysis of large quantity of data. Existing hospital systems are not prepared to gather such detailed and specialized information. This situation stimulated the formation of a group dealing with the infertility treatment as well as software programming. The group also decided to create a suitable system for gathering this type of information.
After a long period of preparations, consultations and tests, the system has been initiated and implemented in the Clinic of Reproduction and Gynecological Endocrinology in Bialystok. The transparent structure and the form of implementation of the system allow it to be used by untrained personnel involved in work with other hospital systems. Data relating to few hundred couples treated for infertility using the IVF ICSI/ET method has been accumulated up to the date of writing of this paper.

Introduction

The character of treatment of infertility requires gathering, storage as well as continuous analysis of large quantity of specialized data, and also the assurance of the possibility of quick access. The hospital information systems are familiar to medical computer specialists [1], however the existing hospital systems are not adapted to accumulate specialized data. Each general system, designed to be applied in the unit of medical care accumulates only the most general data, mainly related to the personal information,

diseases, executed treatment, diagnostic procedures, therapy, medical education as well as the hospital administration [2]. In numerous cases they cover demand of the medical units, resulting from administrative needs and the requirements imposed by the National Health Fund [3]. But it is necessary to find other solutions to gather much more specialized information.

Because of the still changing medical procedures [4], it is not likely to find on the medical software market an application, which will be prepared to gather our specific data. Moreover, one should not expect products which will conduct desirable statistical analyses of the gathered data. The best and probably the only satisfactory solution seems to be the creation of a local system designed by both programmers, as well as personnel who will use this system. Therefore, a team was formed, and its joint effort led to the creation of an application fulfilling the awaiting tasks.

The lack of a specialistic system for registering information concerning patients described above was noted at the Clinic of Reproduction and Gynecological Endocrinology of Medical University of Bialystok. One of the tasks of the clinic is to initiate and conduct the process of treatment of couples suffering from infertility problems. In the process, many complicated procedures are performed, among which a considerable part are procedures related to the process of in vitro fertilization (IVF) joint with intracytoplasmic sperm injection (ICSI), and then with the transfer of the created in this way embryo (ET) into the uterine cavity [4]. So far, the magnitude of information connected with every treated couple was recorded mainly in paper form, which had a restrictive influence on the possibility of the application and the analysis of accumulated data. This situation led to the formation of a group who decided to create a system able to collect data of patients going through the IVF ICSI/ET procedures.

The course of the treatment process of infertility using the IVF ICSI/ET procedure

The work of the team began with a detailed discussion and considering possible decisions relating to the range of accumulated information, as well as the form it will be stored. The pattern of process of treatment which consists of several main stages of accumulating information was created (Fig. 1). In the first order, personal data of the couple which applies for treatment is gathered. Then, information relating to previous treatment, as well as the results of various examinations are collected, including the medical interview of the woman and the man, laboratory tests, and also ultrasonography image
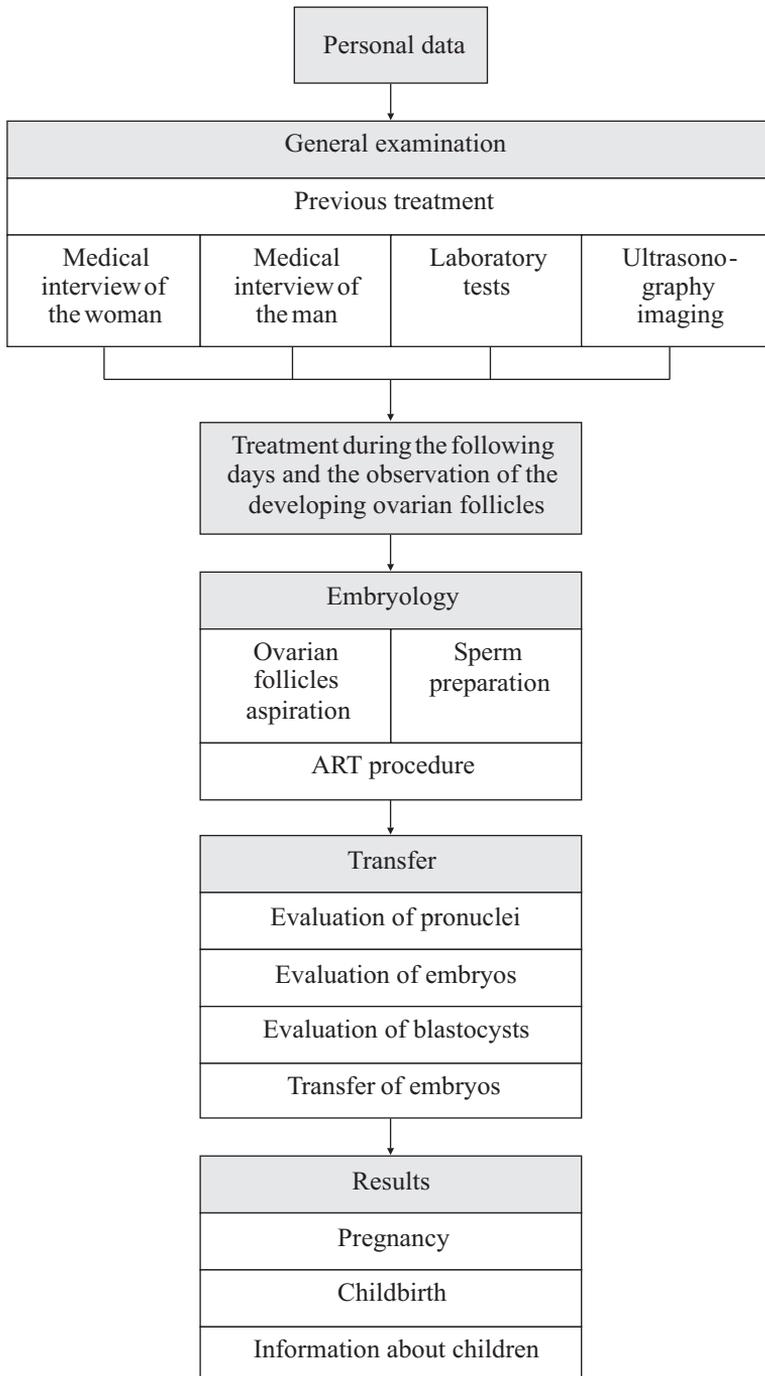
Figure 1. The pattern of the treatment process using the IVF ICSI/ET procedure

and its description. After the end of this stage, the couple is qualified for further treatment, the protocol of stimulation is chosen and the period of treatment begins. Information concerning drugs administered and ovulation stimulation in following days of the treatment process are gathered.

The level of estradiol, thickness of the endometrium, as well as the quantity and the size of the developing ovarian follicles in both ovaries are recorded in the later stage. The following part concerns embryology: the information relating to the process of ovarian follicles aspiration, preparation of sperm and the ART procedure are collected. In the next stage, the information about the developing embryo is gathered until the moment of its transfer. The last part concerns the results of the whole process, where the relating data of the potential pregnancy, childbirth, as well as basic information about children born as a result of the treatment are recorded.

The application handling the infertility treatment process

The application was created in the software development environment Delphi 2007 [5, 6], while the database was implemented using Microsoft Access [7] from the Microsoft Office 2003 software. The database consists of 47 tables, which keep all essential information recorded during the process of treatment. Every table contains several fields of different data type. The key tables are *Cycles*, containing basic information about each cycle of treatment, and also *Couples*, where personal data of treated couples is recorded. The tables are connected with relations of *one to many* type [7], because one couple can have many cycles of treatment registered. The database handling the application contains the information about the couples and the cycles on the main panel, visible in two grids after starting the program (Fig. 2). The system was designed to be used in Poland (there is no English version yet), therefore all print screens contain phrases in the Polish language.

The upper part of the grid allows to add a new couple and to remove or modify the existing one. The window, which appears after selecting option "add a new couple" is shown on (Fig. 3).

The process of addition of a new couple cannot be finished until suitable data is typed in the required fields. These fields concern the information which is indispensable for administrative or contact reasons (name, surname, PESEL number, address, area code and telephone). The information about the added couple is displayed in the upper part of the grid, which also unlocks the possibility of defining following cycles of treatment in the bottom part of the grid.
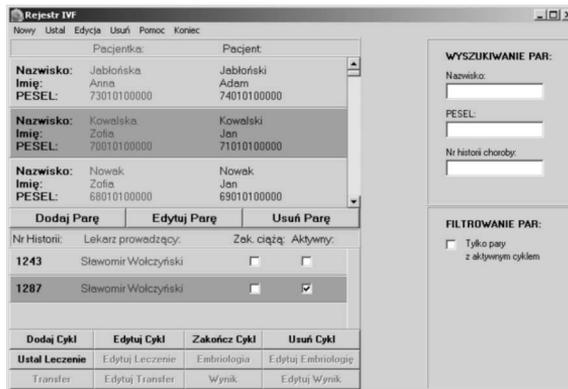
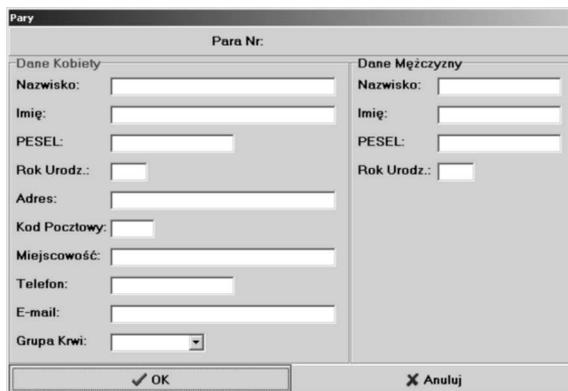**Figure 2.** The grids of patients and the treatment cycles

Figure 3. The window of a new couple addition

There are components for searching patients on the right side of the main application window (Fig. 2). Searching can be done according to three criteria: surname, PESEL number or the number of the case. The possibility of turning on filtering also exists, so only couples which are in the progress of an active cycle are displayed. Filtering according to the active cycle hides the whole history, leaving only presently treated couples.

Not all buttons are active in the cycle part because the process of treatment requires going through subsequent, linearly ordered stages. According to (Fig. 1), first it is necessary to create a new cycle, then plan the treatment, enter information relating to embryology and transfer, and finally enter the results of the treatment.
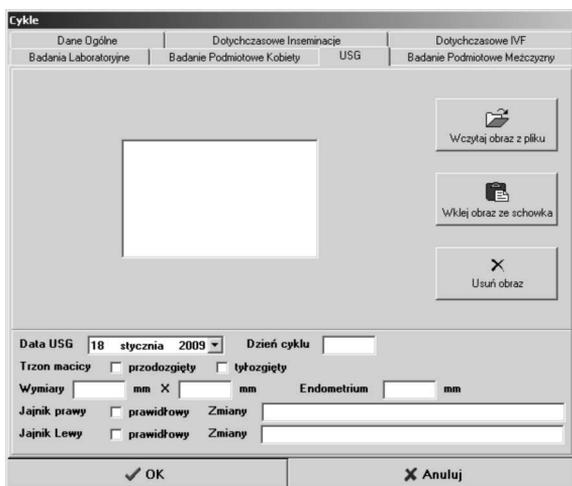
Figure 4. The window of a new cycle addition

The addition of a new cycle to the database is executed in the window (Fig. 4), consisting of 7 tabs:

– General information – identification information relating to the current cycle, physician's data and affirmed infertility causes,
– Previous inseminations – quantity and results of conducted inseminations using husband's (AIH) or donor's (AID) sperm, including division into natural and stimulated cycles,
– Previous IVF – quantity and results of previously conducted cycles of in vitro fertilization, including division into classical IVF cycles, IVF cycles with intracytoplasmic sperm injection (ICSI) and frozen embryos transfer,
– Laboratory tests – dates and results of more than ten laboratory tests, required from the woman before starting the treatment, as well as results of sperm examination,
– Medical interview of the woman – interview includes basic gynecological information, description of ovulation, the course of previous attempts to get pregnant and existing diseases, performed operations and gynecological interventions,
– Ultrasonography – date, description and ultrasonography image,
– Medical interview of the man – interview relating to the man's reproductive history, existing diseases, as well as results of medical examination of testicles, epididymides and vasa deferentia (for patients with severe oligoasthenoteratospermia or azoospermia).

The following tabs allow to enter appropriate data. The ultrasonography

tab deserves a special attention (Fig. 5). It allows to read image recorded during ultrasonography examination of the patient from the disc file or from clipboard. This image, similarly to other data is placed in the database. The application handles different graphical image types: *.jpg, *.jpeg, *.bmp, *.ico, *.emf, *.wmf.

Figure 5. The "ultrasonography" tab of the window of a new cycle addition

After gathering preliminary information, it is required to choose the treatment protocol, which determines the order of proceedings in the first stage of the treatment. There are 11 predefined types of protocols in the database (Tab. 1), which we can divide into 4 main categories:
 – short (protocol 1),
 – long (protocols 2–5),
 – with antagonist (protocols 6–9),
 – other (protocols 10–11).
Individual protocols differ from one another as to the kind, dose and the time of administering the analogs of the GnRH, and the time of administering the hormones FSH, HMG and LH.

The treatment protocol establishing window is shown on (Fig. 6). Protocols can be chosen from the drop-down list. The short profile of the chosen pattern of treatment is displayed in the right side of the window. The date of treatment beginning is also set here, as well as the date of last menstruation. It is also possible to add information about potential contraception applied in the period previous to the current treatment.

Table 1

The kinds and the profile of treatment protocols

ID	Name	aGnRH from day	aGnRH till day	FSH	HMG	LH	from day	till day
1	short 0,05 (1)	1	8	yes	yes	yes	3	8
2	long 0,05 (2)	1	20	yes	yes	yes	15	20
3	long 0,05 (3)	1	14					
4	long 3,75 (4)	1	1					
5	long 3,75 (5)	1	1	yes	yes	yes	15	20
6	with antagonist 0,25 (6)	6	6	yes	yes	yes	1	5
7	with antagonist 3,0 (7)	6	6	yes	yes	yes	1	5
8	with antagonist 0,25 (8)			yes	yes	yes	1	5
9	with antagonist 3,0 (9)			yes	yes	yes	1	5
10	lupron stop 0,1 (10)	1	8					
11	free (11)							
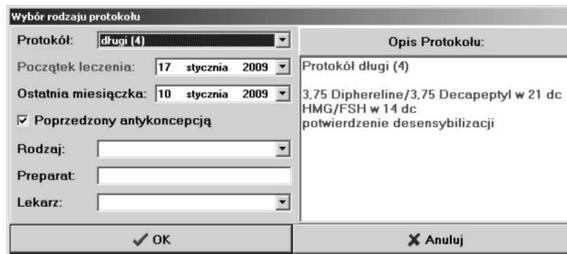
Figure 6. The treatment protocol establishing window

After confirming the chosen protocol, the window of drugs choice and doses of the first phase of the treatment is displayed. The appearance of the window depends on the selected pattern of the protocol (Fig. 7). The choice of drugs and their doses is required to pass on to the next stages. Treatment settled in this way is recorded in the database with division into the following days of treatment and is displayed on a treatment grid (Fig. 8).

It is possible to add new treatment days as well as to edit the existing ones. In the edition window (Fig. 9) it is possible to establish all accessible parameters relating to drugs and their doses. In the further stage also the thickness of the endometrium is defined, as well as the level of estradiol. The sizes of ovarian follicles in both ovaries obtained from ultrasonography imaging are also entered.
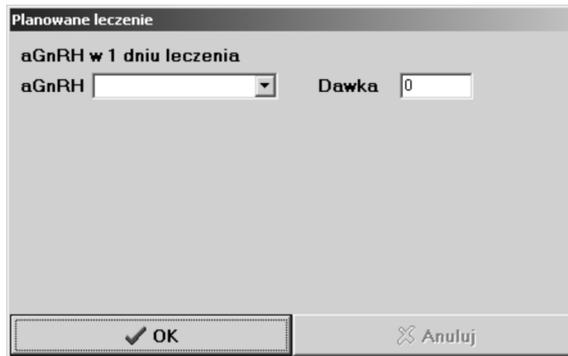
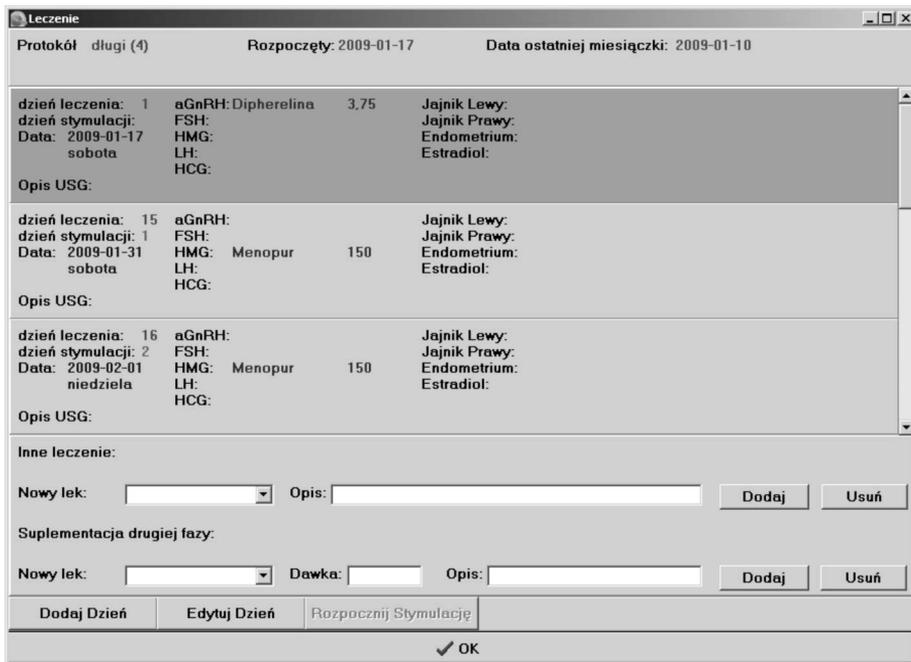**Figure 7.** The drugs and doses of the first phase treatment window

Figure 8. The following days of the treatment grid

The stimulation is initiated in the next step. In the application this procedure is started using "Begin stimulation" button in the following days of the treatment window (Fig. 8). It displays the window of the treatment planning with the possibility of choosing the drugs and their doses for 6 subsequent days of the stimulation (Fig. 10).

Figure 9. The individual day of treatment editing window

Figure 10. The ovulation stimulation planning window

After confirming the treatment the following days are added automatically on the grid of the stimulation window (Fig. 8). Depending on woman's organism response, the stage of stimulation of ovulation can be continued. As it was previously mentioned, the information concerning the developing ovarian follicles is also gathered here. At the moment, when the doctor affirms suitable time to finish the stimulation (the sufficient quantity of the suitably large ovarian follicles, the level of estradiol and the thickness of endometrium) a suitable HCG drug is administered to stimulate the ovulation peak and to make further treatment possible. The day of administering the HCG drug is the last day on the grid in the treatment window (Fig. 8). Application of HCG is required, to enable the opening of a new window. In cycles, without HCG administered yet, pressing the button *Embryology* will display a message about the necessity of HCG application first.

After completing the above described condition, the possibility of beginning the next stage appears. It results in the opening the embryology window (Fig. 11).

Figure 11. The embryology window

The window consists of three tabs, related to three stages of proceeding. These are:
  – The aspiration of ovarian follicles – the time of aspiration, kind of anesthetics, quantity and the category of acquired cumulus oophorus, as well as the doctor's and embryologist's surname,
  – The preparation of semen – the source of sperms, data related to the quality and the volume of semen, preparation of semen as well as the embryologist's surname,
  – The ART procedure – data related to ART procedure, including division into classic case and ICSI, number of acquired oocytes as well as embryologist's surname.
The completion of the embryology window tabs makes possible the advancement to the next stage, which is related to transferring the fertilized ovum into uterine cavity.

Clicking the "Transfer" button results in opening the evaluation and transfer of embryos window (Fig. 12).

This window contains four tabs, related to three stages of proceeding. These are:
  – The evaluation of pronuclei – the time of evaluation, the quantity of pronuclei in individual classes as well as the surname of the person, who performs the evaluation,

Figure 12. The embryos evaluation and transfer window

– The evaluation of embryos – the quantity of received embryos in second and third day of growth, with division into four classes, based on percentage of fragmentation. It is possible to select embryos intended for transfer in this tab,

– The evaluation of blastocysts – the evaluation of the blastocysts in the fifth and sixth day of growth, with division into categories and the surname of the person, who performs the evaluation. This tab also makes possible to define quantity of blastocyst intended to transfer,

– The transfer of embryos – the time of transfer into the uterine cavity, the qualification of the degree of transfer's difficulty and applied probe, the doctor's and the embryologist's surname, the quantity and class of transferred embryos and blastocysts, quantity of frozen embryos.

The completion of four tabs mentioned above allows to pass on to the last stage of the proceeding, in which the information related to the effectiveness of treatment is accumulated (Fig. 13).

Information related to the presence of pregnancy, the number of children, the week of childbirth, the method of childbirth, possible complications, as well as the state, weight and Apgar score of born children are recorded.

The status of the finished cycle of treatment can be changed to inactive by pressing the button "Finish cycle" in the main application window (Fig. 2). It allows to filter out couples with active cycle in progress.

Figure 13. The results window

The final remarks

The created application is the result of co-operation of personnel who perform infertility treatment, as well as personnel who deal with programming. It is also the result of many years of co-operation and detailed consultations, permitting the whole group to acquaint with the subject matter – both with medical aspects and also with the possibilities of the programming environment in which the application was to be implemented.

The created system, as any large application is subject to continuous modification. In the first phase of the system's implementation many problems, both technical, as well as resulting from mistakes in the design stage, were found and improved. After achieving the stage of stability and undergoing tests performed by personnel, who didn't take a part in the design process, the system have been applied at the Clinic of Reproduction and Gynecological Endocrinology of Medical University of Bialystok. Data of few hundred of couples treated for infertility with the IVF ICSI/ET method has been accumulated up to the date of writing of this paper.

Significant improvement of accuracy and the reliability of entered data is one of first noticed effects of applying the system. It mainly is a consequence of the required filling in of some key fields in the database, which answered

the recurrent questions of the lack in data. In comparison to gathering information using paper questionnaires such results would be impossible to accomplish.

The future plans

The created system has been implemented and is functioning properly but this is only the completion of the first stage of planned project. The second crucially important task will be the creation of the statistical module. This module should allow for quick calculation of descriptive statistics with the option of graphic presentation using charts, histograms, tables, and so on. It is intended that this application will enable to define and compare statistic parameters of a group of patients, as well as to calculate statistical significance of the differences. This functionality would simplify significantly the analysis of accumulated data and would also be of great help for the users of the system when taking a decision (for example during the choice of the protocol of the treatment).

The next step of this application's development is implementing it to work in a network, to allow multi-access to data. At present, the application is used on one selected computer. After adaptation to work in the network, many users from different locations could simultaneously add, edit and analyze the patients' data. This stage will enable a stable multi-access to data but also guarantee the safety of gathered information. Access by the Internet causes a whole range of threats to safety, and the confidentiality of recorded information requires putting special pressure on the security aspect.

After the completion of the third stage, it possible that the application will create a large and universal system which could become a standard in accumulation of information by entities performing infertility treatment using IVF methods.

References

[1] Piętka E. Zintegrowany system informacyjny w pracy szpitala. Wydawnictwo Naukowe PWN, Warszawa 2004.
[2] Kącki E., Kulikowski J.L., Nowakowski A., Waniewski E. Systemy komputerowe i teleinformatyczne w służbie zdrowia. Biocybernetyka i Inżynieria Biomedyczna, Akademicka Oficyna Wydawnicza EXIT, Warszawa 2003.

[3] Trąbka W. Szpitalne systemy informatyczne. Uniwersyteckie Wydawnictwo Medyczne Vesalius, Kraków 1999.

[4] Radwan J. Niepłodność i rozród wspomagany. Wydawnictwo Termedia, Poznań 2005.

[5] Boduch A. Delphi 2005. Kompendium programisty. Wydawnictwo Helion 2005.

[6] Wybrańczyk M. Delphi 7 i bazy danych. Wydawnictwo Helion 2003.

[7] Feddema H. Microsoft Access. Podręcznik administratora. Wydawnictwo Helion 2006.

Milewski Robert
Medical University of Bialystok
Department of Statistics and Medical Informatics
Mickiewicza 2c, 15–089 Białystok
milewski@umwb.edu.pl

Jamiołkowski Jacek
Medical University of Bialystok
Department of Public Health
I Armii Wojska Polskiego 2/2, 15–103 Bialystok
jacekj@umwb.edu.pl

Milewska Anna Justyna
Medical University of Bialystok
Department of Statistics and Medical Informatics
Mickiewicza 2c, 15–089 Białystok
milewska@umwb.edu.pl

Domitrz Jan
Medical University of Bialystok
Department of Reproduction and Gynecological Endocrinology
M. Sklodowskiej-Curie 24a, 15–276 Bialystok
jan@domitrz.pl

Wołczyński Sławomir
Medical University of Bialystok
Department of Reproduction and Gynecological Endocrinology
M. Sklodowskiej-Curie 24a, 15–276 Bialystok
wolczynski@sitech.pl