1. Abstract

Infertility is without doubt a serious medical problem. Thus, searching for its causes is currently a very important issue. After oocyte fertilization, its development begins with cleavage, i.e. successive mitotic divisions, first into two blastomeres, then 4, and so on until a morula is formed, consisting of 16-32 blastomeres, which then reaches the stage of the blastocyst. Owing to state-of-the-art technological solutions, it is possible for this process to be carried out in the Embryoscope – an innovative incubator which ensures optimum conditions for the embryo. Most importantly, however, it enables continuous time-lapse monitoring and assessment of each stage of development and thus precise capture and collection of information about the times when successive stages of development are reached, i.e. the dynamics of cleavage divisions, without exposing the embryo to external factors. The recorded parameters include morphokinetic ones such as absolute and relative division times, equal sizes of blastomeres, level of cytoplasmic fragmentation, or the presence of anomalies such as multinucleation or DUC (a phenomenon in which a blastomere divides directly into several, instead of two, daughter blastomeres). Hence, features are noticed that an embryologist would find it impossible to detect in a traditional, static assessment.

The aim of this thesis was to determine which properties of the dynamics of cleavage divisions of a developing embryo translate into its potential of reaching the blastocyst stage. The key issue to be established was which of the embryos carry the best prognosis at possibly the earliest stage after fertilization, so that their transfer to the uterus can be performed as early as possible. The study was based on data describing the development of 4,050 embryos, sourced from the Embryoscope.

Standard statistical analyses showed that those embryos that formed a blastocyst are characterized, on average, by shorter and less spread times of subsequent cell divisions, compared to embryos whose development was arrested at an earlier stage. Using Data Mining methods, however, such as basket analysis, hierarchical and non-hierarchical cluster analysis, classification trees, and artificial neural networks, offered the possibility of a far more effective search for regularities influencing a successful outcome. The methods used are procedures that make it possible to explore large data sets and detect certain non-obvious rules and systematic interdependencies. In this manner, they contribute to a fuller understanding of the studied phenomenon as well as relationships and associations between the analysed characteristics.

The performed studies allowed to prepare good quality classifiers that differentiated embryos in terms of their developmental potential. Particular sets of rules were formulated; when they were met, the probability of reaching the blastocyst stage was high. It was also possible to indicate optimal – from the point of view of the development of an embryo – ranges of morphokinetic parameters.

The Data Mining methods allowed to distinguish clusters of embryos with similar patterns of cell divisions. These classes differed significantly in terms of their potential to reach the blastocyst stage. Studying the structure of their similarities made it possible to determine those regularities that imply, with a high probability, a successful developmental outcome of an embryo. It is important for the first rounds of divisions not to be too short or too prolonged. The presence of successive stages in defined time frames turned out to be conducive to the forming of a blastocyst. Moreover, possibly the most synchronous occurrence of divisions is significant. On the other hand, the performance of the method consisting in identifying clusters of cases with similar schemes of development was unsatisfactory in terms of recognizing those embryos whose development is arrested before they reach the blastocyst stage. For this reason, it seems necessary to continue the search for conditions that would determine the developmental failure of an embryo in a more unambiguous manner.