Mathematics for Diagnosis and Treatment

SCIENCE AND MATHEMATICS

Recent advances in medicine is promoting a new wave of science since the *life science* is anticipated to play a leading role in the coming third generation of the modern science. However, medicine is still immature as a science and it must be brought up to lead the new age of science. Established sciences such as physics, chemistry and engineering have developed from empirical technology but matured through the scientific systematization of the knowledge. Public works in ancient Egypt gave birth to survey engineering through a great support by geometry. Newtonian mechanics was also derived from the empirical technology in astronomical observation and mathematics, i.e., infinitesimal calculus promoted this development. These examples in the history of science could imply that mathematical description is inevitable for the development of new science from empirical technology since mathematics provides four pivotal characteristics to the science; *abstractness, universality, predictability and extensibility*. However, we have not yet found any established proper mathematics to support the medicine. This may be because biological phenomena are too complicated to be described by mathematics. However, medicine could not be a science until a mathematical recognition is achieved.

THE LOGICAL STRUCTURES OF MEDICINE

In general, natural science is composed of scientific recognition and technological action. These two major components represent the instinctive desires of human beings, i.e., the *recognition* and *control* of nature. In other words, we are always seeking the truth (verum) and the goodness (borum) in our daily life. Medicine also has these two major aims, i.e., recognition of patient's pathological conditions and optimal treatment. Thus, medical science has two aspects; "be" science and "do" science. In biology and basic medicine, the laws of biological phenomena have been introduced by analysis of the observed phenomena. This is a typical example of "be" science and principles of the biological phenomena have often been described in mathematical models, e.g., Hodgkin-Huxley's model of iron current across the cell membrane, Hill's model of muscle mechanics, Michaelis-Menten's equation in enzymatic reaction and Guyton's model of the body fluid regulation.

MATHEMATICS FOR CLINICAL MEDICINE

In contrast to basic medicine, clinical medicine mainly focuses on "do" science; the diagnosis of the disease and the optimal treatment of the individual patient. Thus, mathematics for clinical medicine is identical to that for diagnosis and treatment. The process of diagnosis and treatment could be subdivided into 1) measurement of the individual state, 2) recognition of the pathological condition, 3) prediction of the prognosis and 4) control of the disease. In the *measurement*, mathematics provides accuracy and reproducibility. Information sciences based on mathematics expands our ability of measurement both in spacial and time domains as seen in computer tomography and Holter's electrocardiography. In the *recognition*, two mathematical techniques have recently been used; probabilistic method and deterministic method. For the former, multivariate analysis is often applied, and for the latter, the deconvolution technique and inverse model are utilized. The simulation model is also used for mathematical recognition of phenomena. In the *prediction* also, proba-
bilistic model and the deterministic model are proposed in practical use. The Markov process and the multiple logistic model are the examples of the former, and the transfer function determined from the input-output relation and the simulation model are the latter examples. Finally, the control is an action process for the "do" science. This is derived from the cybernetics proposed by N. Wiener in 1946. According to the control theory, observability and controllability are essential conditions for the achievement of the control. The most sophisticated control device in medicine may be an artificial organ. For this also, mathematical description of the biological function plays the most important role. We developed an artificial beta cell for severe diabetic patients. This is becoming practically used since we succeeded in the mathematical description of insulin secretions in a physiological fashion in response to the changes in blood glucose levels. Thus, it is apparent that mathematical description is inevitable for scientific medicine.

In the entire process of clinical medicine, mathematical conception or description serves as a provision for the science. It is needless to say that the mathematics per se is not the aim of the medicine but would be a catalyst for promoting the medicine up to the science. Thus, I believe that the following words might be a torch lamp for the future medicine; "Any medicine in the future will not exist without mathematics."

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