Managing chronic disease with individualized metabolomics & artificial intelligence

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Christopher Gerner from the Joint Metabolome Facility at the University of Vienna, Austria, walks us through what we need to know about managing chronic disease by individualized metabolomics & artificial intelligence

Many acute life-threatening conditions, such as severe injury or bacterial infections, have remained well under control for almost a century. However, chronic diseases such as type 2 diabetes, inflammatory bowel diseases, endometriosis, chronic fatigue syndrome, etc. and the increasing numbers of patients suffering from them still pose a major challenge. The characteristics of such diseases are a slow progression and a rather unclear etiology, making it difficult to give medical advice for individualized metabolomics regarding therapeutic options or the optimization of an individual's lifestyle.

Individualized metabolomics

Genomics to characterize genetic risk factors associated with many diseases built the foundation and first success story of precision medicine. However, the multifactorial nature of chronic diseases impedes causal (in contrast to rather associative) analyses as required to improve the understanding of disease mechanisms. Expanding current precision medicine with post-genomic methods may allow us to determine and monitor relevant molecular patterns in individuals. Such methods would help to identify the homeostatic mechanisms which fail and eventually lead to the development of disease symptoms. In addition, they would allow us to determine the actual impact of any kind of intervention like pharmacological treatment, improved nutrition, physical exercise or control of the exposition to (environmental) toxins on the disease processes.

But the development of such biomedical methods is a significant challenge. An organism deals with innumerable tasks by regulating the metabolism, which is a process network of overwhelming complexity. Metabolism involves many thousands of different molecules and occurs at the level of cells and their organelles, tissues, and the whole organism with relevant time scales covering the range of nanoseconds to years. It may, therefore, hardly surprise us that there is currently no method to assess the metabolism of an individual in its entirety (in contrast to an individual's genome).

Applying artificial intelligence: What is Metabo-tip?

Only recently, a new methodology, termed Metabo-tip, has been developed with promising features.(1) Metabo-tip allows us to perform individual metabolic time course measurements and to investigate metabolic alterations consequent to defined interventions.(2) Importantly, Metabo-tip is non-invasive. Otherwise, the sequential

invasive sampling of an individual would represent an important limitation. Metabo-tip is based on the ultra-sensitive analyses of sweat samples collected from the tip of a finger. The amazing sensitivity of high-resolution mass spectrometry allows us to observe several thousand different molecules, including a large number of potential biomarkers per sample.(3) Currently, Metabo-tip stands out as the only technique capable of short-interval metabolic biomonitoring/phenotyping in humans.(3)

Such methods at hand mean that the biomedical challenge associated with chronic diseases boils down to mathematical problems. Methods for metabolic biomonitoring deliver a large number of data points, which depend on physiological activities affected by multiple factors related to your state of health, lifestyle parameters (eating, smoking, physical exercise) or pharmacological therapy. In this context, a network of molecular parameters will have a stronger predictive power regarding chronic diseases compared to single data points, even if they are not quantitative. This situation is highly reminiscent of the state of social networks about two decades ago. At that time when digital data collection commenced, typically single data points such as a visit to a webpage or an emotional “like” were considered irrelevant. Now social media such as Facebook or Google can categorize any given individual concerning socially relevant properties in an accurate fashion, based on the application of artificial intelligence (AI) algorithms to such apparently “irrelevant” data. Indeed, the continual improvement of AI methods, such as the implementation of causal interference (4) gives us hope to deal with molecular patterns delivered by Metabo-tip in a similar fashion.

The future of managing chronic disease

Actually, there will be some obstacles to overcome in the near future. The current evaluation strategies for diagnostic products and the regulatory apparatus for patent applications are based on quantitation, linear relations and linear causation. For the main part, quantitative values of single parameters are used to diagnose, stratify and monitor patients. However, any diagnostic option or therapeutic strategy for a chronically ill patient must be based on a network of parameters and, thus, will not fit into such a scheme. This fact actually represents a serious obstacle for current scientists to get appropriate research funding and paralyzes the translation of basic research into products of unmet clinical need. Importantly, causal inference algorithms hardly rely on accurate single values but work with multiple constraints applicable to molecular patterns as required for chronic disease management. Indeed, this strategy may thus offer a practical solution to this challenge.

In conclusion, we expect that metabolic biomonitoring by Metabo-tip will have the power to support new diagnostic and treatment strategies when dealing with chronic diseases and, therefore, advance precision medicine and individualized therapy in an unprecedented way.

References

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