NEW APPROACH FOR VISUAL ANALYSIS OF HEALTH MONITORING DATA

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Abstract

At the present time, continuous glucose monitoring (CGM) in Diabetes Mellitus type 1 (T1DM) patients gives diabetologists great amounts of data, which can be applied to analyze patients' glucose variability and, further, estimate pathogenesis of development of diabetes complications. Growing popularity of CGM and easy to use method to analyze and make sense out of great amounts of CGM results may benefit in areas of personal health records for T1DM patients and social networking applications for diabetes professionals.

Keywords

diabetes mellitus type 1, T1DM, continuous glucose monitoring, CGM

Background

The global prevalence of diabetes by International Diabetes Federation (IDF) estimation shows that there were 366 million people with diabetes in 2011, and this amount is expected to rise to 552 million by 2030. Intensive diabetes management has been demonstrated to significantly reduce the complications of type 1 and type 2 diabetes. To accomplish this, subjects have traditionally monitored blood glucose levels at least four times daily. However, intermittent testing has significant limitations and cannot accurately portray the variability in glucose levels that may occur throughout the day.

Initially introduced into clinical practice in 1999 for short term, retrospective analysis of blood glucose control (where review of glucose traces allows healthcare professionals to advise on therapy changes), continuous glucose monitoring (CGM) is also now available for real time use and provides information on direction, magnitude, frequency, and duration of glycaemic fluctuations on a moment to moment basis to aid control of diabetes by patients themselves. So, continuous glucose monitoring, while a relatively new technology, has great potential to transform care for patients with diabetes. Compared with conventional intensified glucose monitoring, continuous monitoring provides much greater insight into glucose levels throughout the day. The currently available CGMs measure blood glucose either with minimal invasiveness through continuous measurement of interstitial fluid (ISF) (Fig. 1) or with the noninvasive method of applying electromagnetic radiation through the skin to blood vessels in the body. The technologies for bringing a sensor into contact with ISF include inserting sensor subcutaneously to measure ISF in situ or harvesting this fluid by various mechanisms that compromise the skin barrier and delivering the fluid to an external sensor.

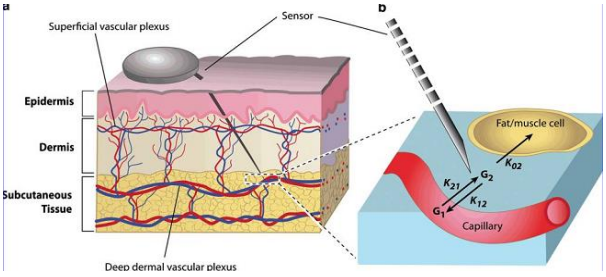

Fig. 1. ISF measurement [1]

These ISF measurement technologies are defined as minimally invasive because they compromise the skin barrier but do not puncture any blood vessels. After a warm-up period of up to 2 h and a device-specific calibration process, each device's sensor will provide a blood glucose reading every 1–10 min. Results are available to the patient in real time or retrospectively.

Visual analysis of continuous glucose monitoring

CGM gives great amounts of concrete glucose level data and made possible for diabetologists to make several assumptions in the glucose level movement in patients with diabetes. First central assumption: the levels are dependent of one another, movement goes in trends. Second: there is uncertainty as to the size of the step between consequent levels, movement encounters situations in which the move varies wildly. Cumulatively, estimation of these two effects for the ongoing movement can help diabetologists and patients to mitigate possible consequences of it. Herein may be applied methods from classical mass data analysis area, stock market.

For eighteen patients with T1DM CGM was performed for consecutive 4 days. Special LabVIEW software was developed to represent the range of glucose movement over each 4-hours interval with candlestick chart (Fig. 2). Candlesticks are composed of the body and the wick. The wick illustrates the highest and lowest glucose levels during the time interval. The body illustrates the opening and closing level. If the glucose level at the end of period lower than at beginning, the body is gray, with the opening level at the top of the body and the closing at the bottom. Otherwise, the body is black.

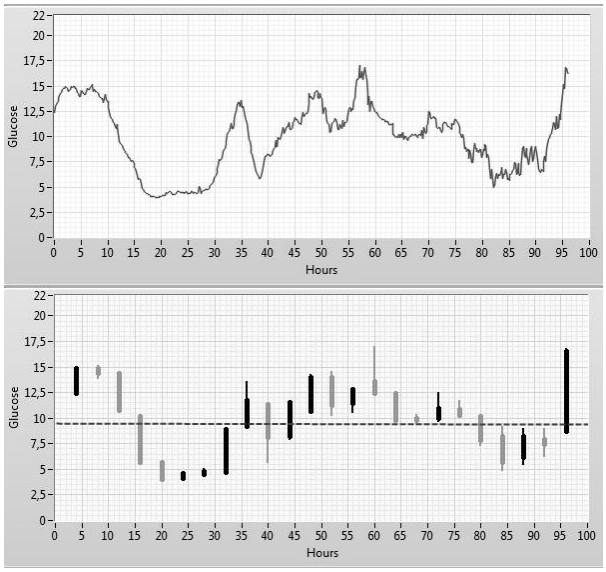

Fig. 2: The range of glucose movement over each 4-hours interval represented with simple graph and a candlestick chart.

Candlestick chart could become a visual aid for decision making in clinical practice, because it generates pictures of ever-increasing amounts of data by using recognizable shapes.

Measuring the velocity and magnitude of directional glucose level movement

Moreover, glucose level movement in patients with diabetes goes in trends. Many variables influence trends, they lead actual developments in underlying fundamental conditions. In everyday practice, diabetologists require relatively quick and easy to use method to anticipate future trends without concern for underlying causes and effects.

Special LabVIEW software was developed to quantify glucose level momentum using the Relative Strength Index (RSI), one of the most popular stock market price momentum indicators (Fig. 3). Mathematically, RSI is represented as: RSI = 100 – (100/(1+RS)), where RS is the ratio of the average of n-period glucose level increases divided by the absolute value (i.e., ignoring sign) of the average of n-period decreases. The RSI computes momentum as the ratio of higher rises to lower losses: T1DM patients which have had more or stronger glucose level rises have a higher RSI than patients which have had more or stronger falls.

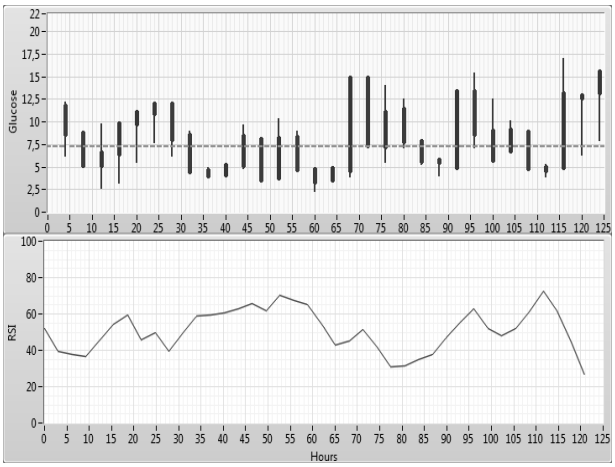

Fig.3: The range of glucose movement over each 4-hours interval represented with a candlestick chart, glucose level momentum quantified using the Relative Strength Index.

RSI is a leading indicator of a change in trend direction. In a typical cycle, glucose level begins a new uptrend with very high and rising momentum. This positive velocity gradually diminishes as glucose reaches high level, as patients use insulin for treatment. The slope of the glucose level advance lessens. Almost invariably, momentum hits its peak well before the glucose hits its ultimate high. RSI decreases more dramatically as glucose rallies begin to fall short of previous peaks on minor rally attempts, depicting a very mature phase of insulin therapy effects.

The level of the RSI is a measure of the glucose level movement recent strength. The slope of the RSI is

directly proportional to the velocity of a change in the trend. The distance traveled by the RSI is proportional to the magnitude of the move. When glucose level moves up very rapidly, at some point it can be considered as signal for patient to use insulin for treatment, likewise, when RSI falls very rapidly. RSI readings greater than the 70 level may be considered as an overhigh territory, and RSI readings lower than the 30 level may be considered as an overlow territory. In between the 30 and 70 level is considered neutral, with the 50 level a sign of no trend.

Usage of RSI in everyday practice is a easy to use method to anticipate future glucose level movement trends without concern for underlying causes and effects.

Conclusion

Methods from classical mass data analysis area, stock market, may benefit for health monitoring data applications in medicine. As candlestick chart could become a visual aid for decision making in clinical practice. Moreover, RSI may be considered as an objective and orderly mean for diabetologists and patients to translate phenomena of glucose variability into a number, anticipate possible effects of glucose level movement trend, and build an overall theory of decision making basing on this.

Growing popularity of health monitoring and easy to use method to analyze and make sense out of great amounts of results may benefit in areas of personal health records for patients and social networking applications for diabetes professionals.

References

[1] Rebrin, Kerstin, Steil et al., Am. J. Physiol. 277 (Endocrinol. Metab. 40): E561–E571, 1999.

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