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The GH-Method

Viscoelastic Medicine theory (VMT #427): Severity of type 2 diabetes and its damages in four clinic cases using both simple statistics and geometry method with Viscoplastic Energy Model of GH-Method: Math-Physical Medicine (No. 1029)

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Abstract

In his previous paper, No.091 published in 2019, the author used simple statistics and a geometric representation method to create an "OHCA Model" (open-high-close-average) by analyzing any PPG waveform. The OHCA values are listed as follows: - Open at 0 minutes; - High at 60-75 minutes; - Close at 180 minutes; - Averaged PPG over 180 minutes.

In his previous study of No.091, data was collected from four patients:
Case A (the author): Initially in a severe stage, this patient had endured five cardiac incidents among other complications; however, through dedication to a lifestyle improvement program, his case is now well-managed.
Case B: This patient experienced chest pain but has been managed effectively through a lifestyle improvement program.
Case C: Starting at a severe stage after a minor stroke, this patient has seen less optimal control due to a low-carb diet but inadequate exercise.
Case D: Initially at a severe stage and on a heavy medication regimen, this patient's symptoms are managed by medications and lifestyle changes.

In summary, from the vertical axis of the simple triangular OHCA diagram, the PPG triangles are ranked, from the top location of the severe condition to the bottom location of the better-controlled condition, as follows:
Case C > Case D > Case A > Case B
(The greater sign of ">" means the higher position on the y-axis of the OHAC diagram).

Through the more sophisticated engineering method of the space-domain viscoplastic energy model, the energy associated with each case is ranked from high energy to low energy as follows: Case C = 30%; Case D = 26%; Case A = 23%; Case B = 22%.

The energy is calculated based on input stresses (4 clinic cases) associated with the author's collected CGM sensor PPG waveforms between 5/5/2018 to 2/4/2024 as the output strain. The energy level indicates the degree of diabetic damage on the body and the likelihood of developing mortality complications such as CVD, Stroke, CKD, neuropathy, retinopathy, dementia, and cancers. These scientific conclusions align with those of medical doctor's diagnoses and judgments who treat these four patients.

Key message:
Healthcare professionals understand that elevated PPG levels are correlated with higher HbA1C and higher risks. Additionally, the author, who is a mathematician and engineer, has demonstrated that increased glucose levels lead to greater energy, resulting in potential damage to the body and an increased risk of developing life-threatening diseases.

Keywords: Viscoelastic; Viscoplastic; Diabetes; Glucose; Insulin; Hyperglycemia; Neuropathy

Abbreviations: CGM: continuous glucose monitoring; T2D: type 2 diabetes; PPG: postprandial plasma glucose; FPG: fasting plasma glucose; SD: space-domain; VMT: viscoelastic medicine theory; FFT: Fast Fourier Transform

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1. INTRODUCTION

In his previous paper, No.091 published in 2019, the author used simple statistics and a geometric representation method to create an "OHCA Model" (open-high-close-average) by analyzing any PPG waveform. The OHCA values are listed as follows:

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Case A (the author):
Initially, in a severe stage, this patient had endured five cardiac incidents among other complications; however, through dedication to a lifestyle improvement program, his case is now well-managed.

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Starting at a severe stage after a minor stroke, this patient has seen less optimal control due to a low-carb diet but inadequate exercise.

Case D:
Initially at a severe stage and on a heavy medication regimen, this patient's symptoms are managed by medications and lifestyle changes.

Partial abstract of the author's previous paper No. 091:

The author categorizes CGM sensor glucose values into five stages:

Stage 1 (Initial): PPG below 80 mg/dL

Stage 2 (Light): PPG ranges from 80 to 100 mg/dL

Stage 3 (Medium): PPG ranges from 100 to 120 mg/dL

Stage 4 (Heavy): PPG ranges from 120 to 150 mg/dL

Stage 5 (Severe): PPG exceeds 150 mg/dL

This simplified triangular geometry simulation model was developed using 1,344 CGM sensor PPG waveforms and 16,128 PPG data points collected by the author (Case A) over 448 days (from May 5, 2018, to July 26, 2019).

The triangular PPG diagram includes five key elements:

B-open: Right endpoint of the baseline, indicating "Open glucose"

B-close: Left endpoint of the baseline, indicating "Close glucose"

B-mid: Midpoint of the baseline, located "1/3 distance from Open glucose"

T-high: Triangle's top peak-point, indicating "High glucose"

C-average: Triangle's center point, near the "Averaged sensor glucose"

Four clinical cases utilized this model to estimate their PPG values:

Case A (72-year-old male, 25 years with T2D)

B-mid: 128 mg/dL (Stage 4)

Peak PPG: T-high: 147 mg/dL (Finger: 118 mg/dL)

Average PPG (C-average): 136 mg/dL

Case B (71-year-old female, 22 years with T2D)

B-mid: 123 mg/dL (Stage 4)

Peak PPG: T-high: 141 mg/dL (Finger: 113 mg/dL)

Average PPG (C-average): 131 mg/dL

Case C (75-year-old male, 20 years with T2D)

B-mid: 139 mg/dL (Stage 5)

Peak PPG: T-high: 192 mg/dL (Finger: 154 mg/dL)

Average PPG (C-average): 164 mg/dL

Case D (46-year-old female, 10 years with T2D)

B-mid: 129 mg/dL (Stage 4)

Peak PPG: T-high: 166 mg/dL (Finger: 133 mg/dL)

Average PPG (C-average): 148 mg/dL

1.1 Biomedical and Engineering or Technical information:

The following sections contain excerpts and concise information meticulously reviewed by the author of this paper. The author has adopted this approach as an alternative to including a conventional reference list at the end of this document, with the intention of optimizing his valuable research time. It is essential to clarify that these sections do not constitute part of the author's original contribution but have been included to aid the author in his future reviews and offer valuable insights to other readers with an interest in these subjects.

Pathophysiological explanations of hyperglycemia and higher associated energy which damages body and increases risk of mortality diseases:

When blood glucose levels are elevated (hyperglycemia), the body's normal physiological processes can be disrupted, leading to various detrimental effects on health and increasing the risk of developing serious diseases. The related pathophysiological explanations for how hyperglycemia and elevated energy levels can damage the body and increase the risk of developing mortality diseases include:

Oxidative Stress:
High glucose levels can lead to increased production of reactive oxygen species (ROS) within the body, causing oxidative damage to cells, tissues, and organs. This oxidative stress can result in inflammation, impaired cellular function, and damage to DNA, proteins, and lipids, contributing to the development of chronic diseases such as cardiovascular disease, neurodegenerative disorders, and cancer.

Advanced Glycation End Products (AGEs):
Elevated glucose levels can lead to the formation of advanced glycation end products, which are harmful compounds formed when sugars react with proteins and lipids. Accumulation of AGEs can contribute to tissue damage, impaired vascular function, and increased risk of cardiovascular complications, as well as promoting inflammation and tissue fibrosis.

Endothelial Dysfunction:
Hyperglycemia can impair the function of endothelial cells lining the blood vessels, leading to reduced vasodilation, increased vascular permeability, and a prothrombotic state. Endothelial dysfunction contributes to the development of atherosclerosis, hypertension, and microvascular complications such as diabetic nephropathy and retinopathy.

Mitochondrial Dysfunction:
High glucose levels can negatively impact mitochondrial function, leading to impaired energy production, increased generation of ROS, and disruption of cellular metabolism. Mitochondrial dysfunction is implicated in the pathogenesis of various diseases, including cardiovascular disorders, neurodegenerative diseases, and metabolic syndromes.

Inflammatory Response:
Hyperglycemia can trigger an inflammatory response within the body, leading to the release of pro-inflammatory cytokines and the activation of immune cells. Chronic low-grade inflammation associated with elevated glucose levels can contribute to insulin resistance, atherosclerosis, and the progression of various chronic diseases.

Activation of Pathological Pathways:
High glucose levels can activate pathological signaling pathways, such as the hexosamine biosynthetic pathway, protein kinase C pathway, and receptor for advanced glycation end products (RAGE) signaling, leading to dysregulation of cellular processes, aberrant gene expression, and tissue damage.

These pathophysiological mechanisms collectively contribute to the detrimental effects of hyperglycemia and elevated energy levels on the body, increasing the risk of mortality diseases such as cardiovascular disease, stroke, chronic kidney disease, neuropathy, retinopathy, dementia, and certain cancers. Efforts to control blood glucose levels and mitigate the associated pathophysiological processes are essential in reducing the risk of developing these serious health complications.

1.2 MPM Background:

To learn more about his developed GH-Method: math-physical medicine (MPM) methodology, readers can read the following three papers selected from his published 760+ papers.

The first paper, No. 386 (Reference 1) describes his MPM methodology in a general conceptual format. The second paper, No. 387 (Reference 2) outlines the history of his personalized diabetes research, various application tools, and the differences between the biochemical medicine (BCM) approach versus the MPM approach. The third paper, No. 397 (Reference 3) depicts a general flow diagram containing ~10 key MPM research methods and different tools.

The author's diabetes history:

The author has been a severe T2D patient since 1995. He weighed 220 lb. (100 kg) at that time. By 2010, he still weighed 198 lb. with an average daily glucose of 250 mg/dL (HbA1C at 10%). During that year, his triglycerides reached 1161 (high risk for CVD and stroke) and his albumin-creatinine ratio (ACR) at 116 (high risk for chronic kidney disease). He also suffered from five cardiac episodes within a decade. In 2010, three independent physicians warned him regarding the need for kidney dialysis treatment and the future high risk of dying from his severe diabetic complications.

In 2010, he decided to self-study endocrinology with an emphasis on diabetes and food nutrition. He spent the entire year of 2014 developing a metabolism index (MI) mathematical model. During 2015 and 2016, he developed four mathematical prediction models related to diabetes conditions: weight, PPG, fasting plasma glucose (FPG), and HbA1C (A1C). Through using his developed mathematical metabolism index (MI) model and the other four glucose prediction tools, by the end of 2016, his weight was reduced from 220 lbs. (100 kg) to 176 lbs. (89 kg), waistline from 44 inches (112 cm) to 33 inches (84 cm), average finger-piercing glucose from 250 mg/dL to 120 mg/dL, and A1C from 10% to ~6.5%. One of his major accomplishments is that he has no longer taken any diabetes-related medications since 12/8/2015.

In 2017, he achieved excellent results on all fronts, especially his glucose control. However, during the pre-COVID period, including both 2018 and 2019, he traveled to ~50 international cities to attend 65+ medical conferences and made ~120 oral presentations. This hectic schedule inflicted damage to his diabetes control caused by stress, dining out frequently, post-meal exercise disruption, and jet lag, along with the overall negative metabolic impact from the irregular life patterns; therefore, his glucose control was somewhat affected during the two-year traveling period of 2018-2019.

He started his COVID-19 self-quarantined life on 1/19/2020. By 10/16/2022, his weight was further reduced to ~164 lbs. (BMI 24.22) and his A1C was at 6.0% without any medication intervention or insulin injection. In fact, with the special COVID-19 quarantine lifestyle since early 2020, not only has he written and published ~500 new research articles in various medical and engineering journals, but he has also achieved his best health conditions for the past 27 years. These achievements have resulted from his non-traveling, low-stress, and regular daily life routines. Of course, his in-depth knowledge of chronic diseases, sufficient practical lifestyle management experiences, and his own developed high-tech tools have also contributed to his excellent health improvements.

On 5/5/2018, he applied a continuous glucose monitoring (CGM) sensor device on his upper arm and checked his glucose measurements every 5 minutes for a total of 288 times each day. Furthermore, he extracted the 5-minute intervals from every 15-minute interval for a total of 96 glucose data each day stored in his computer software.

Through the author's medical research work of over 40,000 hours and reading over 4,000 published medical papers online in the past 13 years, he discovered and became convinced that good life habits of not smoking, moderate or no alcohol intake, avoiding illicit drugs; along with eating the right food with well-balanced nutrition, persistent exercise, having a sufficient and good quality of sleep, reducing all kinds of unnecessary stress, maintaining a regular daily life routine contribute to the risk reduction of having many diseases, including CVD, stroke, kidney problems, micro blood vessels issues, peripheral nervous system problems, and even cancers and dementia. In addition, a long-term healthy lifestyle can even "repair" some damaged internal organs, with different required time lengths depending on the particular organ's cell lifespan. For example, he has "self-repaired" about 35% of his damaged pancreatic beta cells during the past 10 years.

Energy theory:

The human body and organs have around 37 trillion live cells which are composed of different organic cells that require energy infusion from glucose carried by red blood cells; and energy consumption from labor-work or exercise. When the residual energy (resulting from the plastic glucose scenario) is stored inside our bodies, it will cause different degrees of damage or influence to many of our internal organs.

According to physics, energies associated with the glucose waves are proportional to the square of the glucose amplitude. The residual energies from elevated glucose are circulating inside the body via blood vessels which then impact all of the internal organs to cause different degrees of damage or influence, e.g. diabetic complications. Elevated glucose (hyperglycemia) causes damage to the structural integrity of blood vessels. When it combines with both hypertension (rupture of arteries) and hyperlipidemia (blockage of arteries), CVD or Stroke happens. Similarly, many other deadly diseases could result from these excessive energies which would finally shorten our lifespan. For example, the combination of hyperglycemia and hypertension would cause micro-blood vessel leakage in kidney systems which is one of the major causes of CKD.

The author then applied Fast Fourier Transform (FFT) operations to convert the input wave from a time domain into a frequency domain. The y-axis amplitude values in the frequency domain indicate the proportional energy levels associated with each different frequency component of input occurrence. Both output symptom value (i.e. strain amplitude in the time domain) and output symptom fluctuation rate (i.e. the strain rate and strain frequency) are influencing the energy level (i.e. the Y-amplitude in the frequency domain).

Currently, many people live a sedentary lifestyle and lack sufficient exercise to burn off the energy influx which causes them to become overweight or obese. Being overweight and having obesity leads to a variety of chronic diseases, particularly diabetes. In addition, many types of processed food add unnecessary ingredients and harmful chemicals that are toxic to the bodies, which lead to the development of many other deadly diseases, such as cancers. For example, ~85% of worldwide diabetes patients are overweight, and ~75% of patients with cardiac illnesses or surgeries have diabetes conditions.

In engineering analysis, when the load is applied to the structure, it bends or twists, i.e. deforms; however, when the load is removed, it will either be restored to its original shape (i.e, elastic case) or remain in a deformed shape (i.e. plastic case). In a biomedical system, the glucose level will increase after eating carbohydrates or sugar from food; therefore, the carbohydrates and sugar function as the energy supply. After having labor work or exercise, the glucose level will decrease. As a result, the exercise burns off the energy, which is similar to load removal in the engineering case. In the biomedical case, both processes of energy influx and energy dissipation take some time which is not as simple and quick as the structural load removal in the engineering case. Therefore, the age difference and 3 input behaviors are "dynamic" in nature, i.e. time-dependent. This time-dependent nature leads to a "viscoelastic or viscoplastic" situation. For the author's case, it is "viscoplastic" since most of his biomarkers are continuously improved during the past 13-year time window.

Time-dependent output strain and stress of (viscous input*output rate):

Hooke's law of linear elasticity is expressed as:

Strain (ε: epsilon) = Stress (σ: sigma) / Young's modulus (E)

For biomedical glucose application, his developed linear elastic glucose theory (LEGT) is expressed as:

PPG (strain) = carbs/sugar (stress) * GH.p-Modulus (a positive number) + post-meal walking k-steps * GH.w-Modulus (a negative number)

where GH.p-Modulus is the reciprocal of Young's modulus E.

However, in viscoelasticity or viscoplasticity theory, the stress is expressed as:

Stress = viscosity factor (η: eta) * strain rate (dε/dt)

where strain is expressed as Greek epsilon or ε.

In this article, in order to construct an "ellipse-like" diagram in a stress-strain space domain (e.g., "hysteresis loop") covering both the positive side and negative side of space, he has modified the definition of strain as follows:

Strain = (body weight at a certain specific time instant)

He also calculates his strain rate using the following formula:

Strain rate = (body weight at next time instant) - (body weight at present time instant)

The risk probability % of developing into CVD, CKD, and Cancer is calculated based on his developed metabolism index model (MI) in 2014. His MI value is calculated using inputs of 4 chronic conditions, i.e. weight, glucose, blood pressure, and lipids; and 6 lifestyle details, i.e. diet, drinking water, exercise, sleep, stress, and daily routines. These 10 metabolism categories further contain ~500 elements with millions of input data collected and processed since 2010. For individual deadly disease risk probability %, his mathematical model contains certain specific weighting factors for simulating certain risk percentages associated with different deadly diseases, such as metabolic disorder-induced CVD, stroke, kidney failure, cancers, dementia; artery damage in heart and brain, micro-vessel damage in kidney, and immunity-related infectious diseases, such as COVID death.

Some of the explored deadly diseases and longevity characteristics using the viscoplastic medicine theory (VMT) include stress relaxation, creep, hysteresis loop, and material stiffness, damping effect based on time-dependent stress and strain which are different from his previous research findings using linear elastic glucose theory (LEGT) and nonlinear plastic glucose theory (NPGT).

2. RESULTS

Figure 1 shows Input information, TD and SD results.

3. CONCLUSION

In summary, from the vertical axis of the simple triangular OHCA diagram, the PPG triangles are ranked, from the top location of the severe condition to the bottom location of the better-controlled condition, as follows:

Case C > Case D > Case A > Case B

(The greater sign of ">" means the higher position on the y-axis of the OHAC diagram).

Through the more sophisticated engineering method of the space-domain viscoplastic energy model, the energy associated with each case is ranked from high energy to low energy as follows:

Case C = 30%
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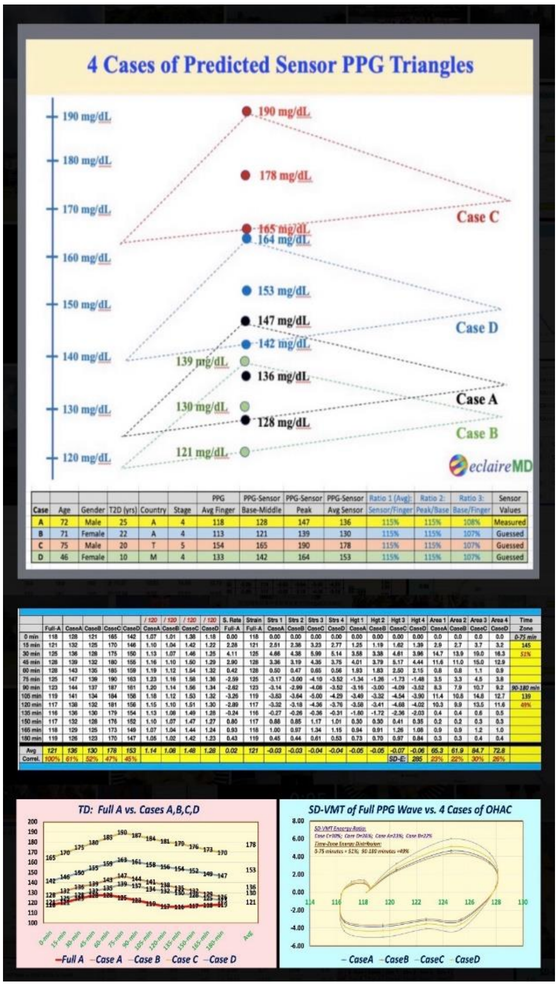

Case	Age	Gender	T2D (yrs)	Country	Stage	PPG Avg Finger	PPG-Sensor Base-Middle	PPG-Sensor Peak	PPG-Sensor Avg Sensor	Ratio 1 (Avg): Sensor/Finger	Ratio 2: Peak/Base	Ratio 3: Base/Finger	Sensor Values
A	72	Male	25	A	4	118	128	147	136	115%	115%	108%	Measured
B	71	Female	22	A	4	113	121	139	130	115%	115%	107%	Guessed
C	75	Male	20	T	5	154	165	190	178	115%	115%	107%	Guessed
D	46	Female	10	M	4	133	142	164	153	115%	115%	107%	Guessed

	Full-A	CaseA	CaseB	CaseC	CaseD	/ 120 CaseA	/ 120 CaseB	/ 120 CaseC	/ 120 CaseD	S. Rate Full-A	Strain Full-A	Strs 1 CaseA	Strs 2 CaseB	Strs 3 CaseC	Strs 4 CaseD	Hgt 1 CaseA	Hgt 2 CaseB	Hgt 3 CaseC	Hgt 4 CaseD	Area 1 CaseA	Area 2 CaseB	Area 3 CaseC	Area 4 CaseD	Time Zone
0 min	118	128	121	165	142	1.07	1.01	1.38	1.18	0.00	118	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0-75 min
15 min	121	132	125	170	146	1.10	1.04	1.42	1.22	2.28	121	2.61	2.38	3.23	2.77	1.25	1.19	1.62	1.39	2.9	2.7	3.7	3.2	145
30 min	125	136	128	175	150	1.13	1.07	1.46	1.25	4.11	125	4.66	4.38	5.99	5.14	3.58	3.38	4.61	3.96	14.7	13.9	19.0	16.3	51%
45 min	128	139	132	180	155	1.16	1.10	1.50	1.29	2.90	128	3.36	3.19	4.35	3.75	4.01	3.79	5.17	4.44	11.6	11.0	15.0	12.9	
60 min	128	143	135	185	159	1.19	1.12	1.54	1.32	0.42	128	0.50	0.47	0.65	0.56	1.93	1.83	2.50	2.15	0.8	0.8	1.1	0.9	
75 min	125	147	139	190	163	1.23	1.16	1.58	1.36	-2.59	125	-3.17	-3.00	-4.10	-3.52	-1.34	-1.26	-1.73	-1.48	3.5	3.3	4.5	3.8	
90 min	123	144	137	187	161	1.20	1.14	1.56	1.34	-2.62	123	-3.14	-2.99	-4.08	-3.52	-3.16	-3.00	-4.09	-3.52	8.3	7.9	10.7	9.2	90-180 min
105 min	119	141	134	184	158	1.18	1.12	1.53	1.32	-3.26	119	-3.83	-3.64	-5.00	-4.29	-3.49	-3.32	-4.54	-3.90	11.4	10.8	14.8	12.7	139
120 min	117	138	132	181	156	1.15	1.10	1.51	1.30	-2.89	117	-3.32	-3.18	-4.36	-3.76	-3.58	-3.41	-4.68	-4.02	10.3	9.9	13.5	11.6	49%
135 min	116	136	130	179	154	1.13	1.08	1.49	1.28	-0.24	116	-0.27	-0.26	-0.36	-0.31	-1.80	-1.72	-2.36	-2.03	0.4	0.4	0.6	0.5	
150 min	117	132	128	176	152	1.10	1.07	1.47	1.27	0.80	117	0.88	0.85	1.17	1.01	0.30	0.30	0.41	0.35	0.2	0.2	0.3	0.3	
165 min	118	129	125	173	149	1.07	1.04	1.44	1.24	0.93	118	1.00	0.97	1.34	1.15	0.94	0.91	1.26	1.08	0.9	0.9	1.2	1.0	
180 min	119	126	123	170	147	1.05	1.02	1.42	1.23	0.43	119	0.45	0.44	0.61	0.53	0.73	0.70	0.97	0.84	0.3	0.3	0.4	0.4	
Avg	121	136	130	178	153	1.14	1.08	1.48	1.28	0.02	121	-0.03	-0.03	-0.04	-0.04	-0.05	-0.05	-0.07	-0.06	65.3	61.9	84.7	72.8	
Correl.	100%	61%	52%	47%	45%													SD-E:	285	23%	22%	30%	26%	

Figure 1: Input Information, TD and SD results

the degree of diabetic damage on the body and the likelihood of developing mortality complications such as CVD, Stroke, CKD, neuropathy, retinopathy, dementia, and cancers. These scientific conclusions align with those of medical doctors' diagnoses and judgments who treat these four patients.

Key message:

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4. REFERENCES

For editing purposes, the majority of the references in this paper, which are self-references, have been removed from this article. Only references from other authors' published sources remain. The bibliography of the author's original self-references can be viewed at www.eclairemd.com.

Readers may use this article as long as the work is properly cited, and their use is educational and not for profit, and the author's original work is not altered.

For reading more of the author's published VGT or FD analysis results on medical applications, please locate them through platforms for scientific research publications, such as ResearchGate, Google Scholar, etc.

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Viscoelastic and Viscoplastic Glucose Theory Application in Medicine

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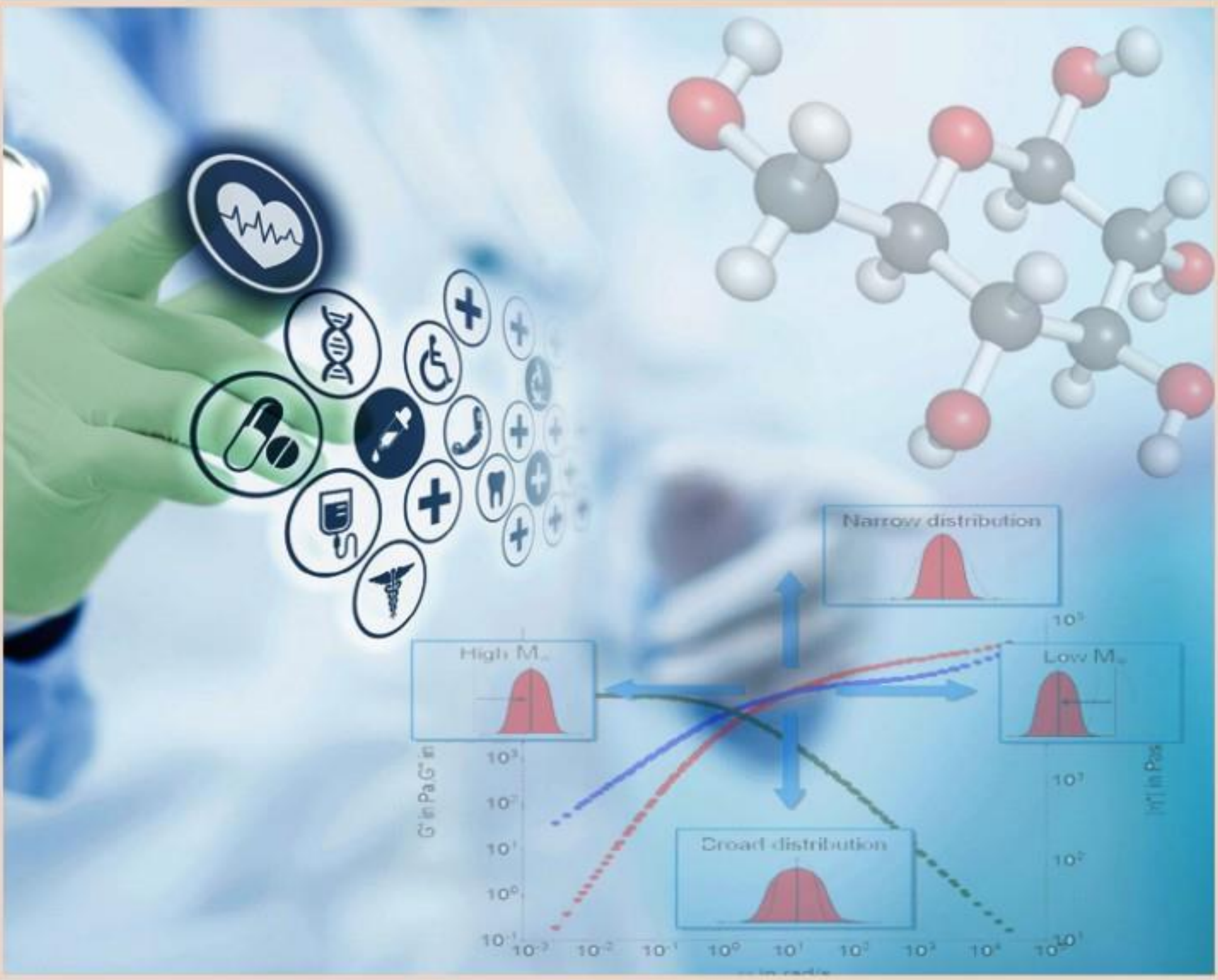

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