Hyperglycemia I - Part Five

DAY ONE		
# of hours fasted	12	
# of hours slept	7.5	
quality of sleep	better than average, woke	
what you ate for breakfast	collagen protein, butter, co	
what you ate for lunch	carrot, salmon, 1/2 sweet p	
	Time	Result
AM Fasting	7:35a	94
Before Lunch	12:05p	98
After Lunch (45-min)	12:50p	122
After Lunch (1-hour later)	1:50p	109
After Lunch (1-hour later)	2:50p	93
DAY TWO		
# of hours fasted	12	
# of hours slept	8	
quality of sleep	a little better, woke only 2 t	
what you ate for breakfast	blueberries, banana, spina	
what you ate for lunch	ginger juice, shrimp, duck	
	Time	Result
AM Fasting	8:45a	91
Before Lunch	1:45p	94
After Lunch (45-min)	3:00p	118
After Lunch (1-hour later)	4:00p	105
After Lunch (1-hour later)	5:00p	89
DAY THREE		
# of hours fasted	12	
# of hours slept	6.5	
quality of sleep	not as good; anxiety before	
what you ate for breakfast	eggs, tomatoes, grapes	
what you ate for lunch	1 cup of white rice with no	
	Time	Result
AM Fasting	7:30a	95
Before Lunch	11:20a	93
After Lunch (45-min)	12:30p	165
After Lunch (1-hour later)	1:30p	132
After Lunch (1-hour later)	2:30p	102

Okay, here's an example test result. In this case, the patient didn't fill out how he felt. The purpose of that is to help people connect how they feel to their blood sugar, and most patients do fill that out, but for whatever reason, this one didn't. You'll notice that this patient has high-normal fasting values on all days, but days one and two with his usual low-carb lunch, the patient didn't have any

spikes, but on day three when he ate white rice, he had a spike of blood sugar up to 165 45 minutes after the meal, which is above the 140 mg/dL cutoff. Then the patient still had elevated blood sugar two hours post-meal. It should be below 120, and it was at 132. Three hours after, it was still a little elevated compared to the fasting value before lunch. So this patient may need a longer-term lower-carbohydrate diet, or it's possible that addressing HPA axis and gut can improve carbohydrate tolerance. If the patient eats something such as rice, he may need to eat a significant amount of fat in order to keep the blood sugar from spiking like that, but this is the great thing about how a glucometer can be used. They can make these kind of changes and then retest with a glucometer to objectively determine their carbohydrate tolerance.

DAY ONE			
# of hours fasted	12		
# of hours slept	8		
quality of sleep	Good. Woke up 1 time		
what you ate for breakfast	Yams, white rice, porriage, 1 egg with no yolk,		
what you ate for lunch	White rice, boiled chicken, cabbage, celery, napa cabbage, carrots		
	Time	Result	How did you feel at the time of measurement (2-3 words)
AM Fasting	8:50am	96	Good
Before Lunch	12pm	111	Good. Rested at home, didn't go out.
After Lunch (45-min)	1pm	110	Good. Rested at home, didn't go out.
After Lunch (1-hour later)	2:10pm	93	Good. Rested at home, didn't go out
After Lunch (1-hour later)	3:10pm	80	Good. Rested at home, didn't go out.
DAY TWO			
# of hours fasted	12		
# of hours slept	8		
quality of sleep	average. not as well as yesterday		
what you ate for breakfast	yams, white rice, porriage, 1 egg with no yolk.		
what you ate for lunch	white rice, boiled chicken, cabbage, celery, napa cabbage, carrots		
	Time	Result	How did you feel at the time of measurement (2-3 words)
AM Fasting	8:15am	88	Good Good
Before Lunch	12:10pm	77	Hungry. Hungry.
After Lunch (45-min)	1:15pm	134	
After Lunch (1-hour later)	2:15pm	88	
After Lunch (1-hour later)	3:15pm	84	
DAY THREE			
# of hours fasted	12		
# of hours slept	8		
quality of sleep	Not good. Woke up at 4-5am. Noisy neighbors		
what you ate for breakfast	yams, white rice, porriage, 1 egg with no yolk.		
what you ate for lunch	white rice, boiled chicken, cabbage, celery, napa cabbage, carrots		
	Time	Result	How did you feel at the time of measurement (2-3 words)
AM Fasting	8am	69	Hungry. Did not eat for dinner last night.
Before Lunch	12pm	59	
After Lunch (45-min)	1:10pm	82	
After Lunch (1-hour later)	2:10pm	85	
After Lunch (1-hour later)	3:10pm	90	

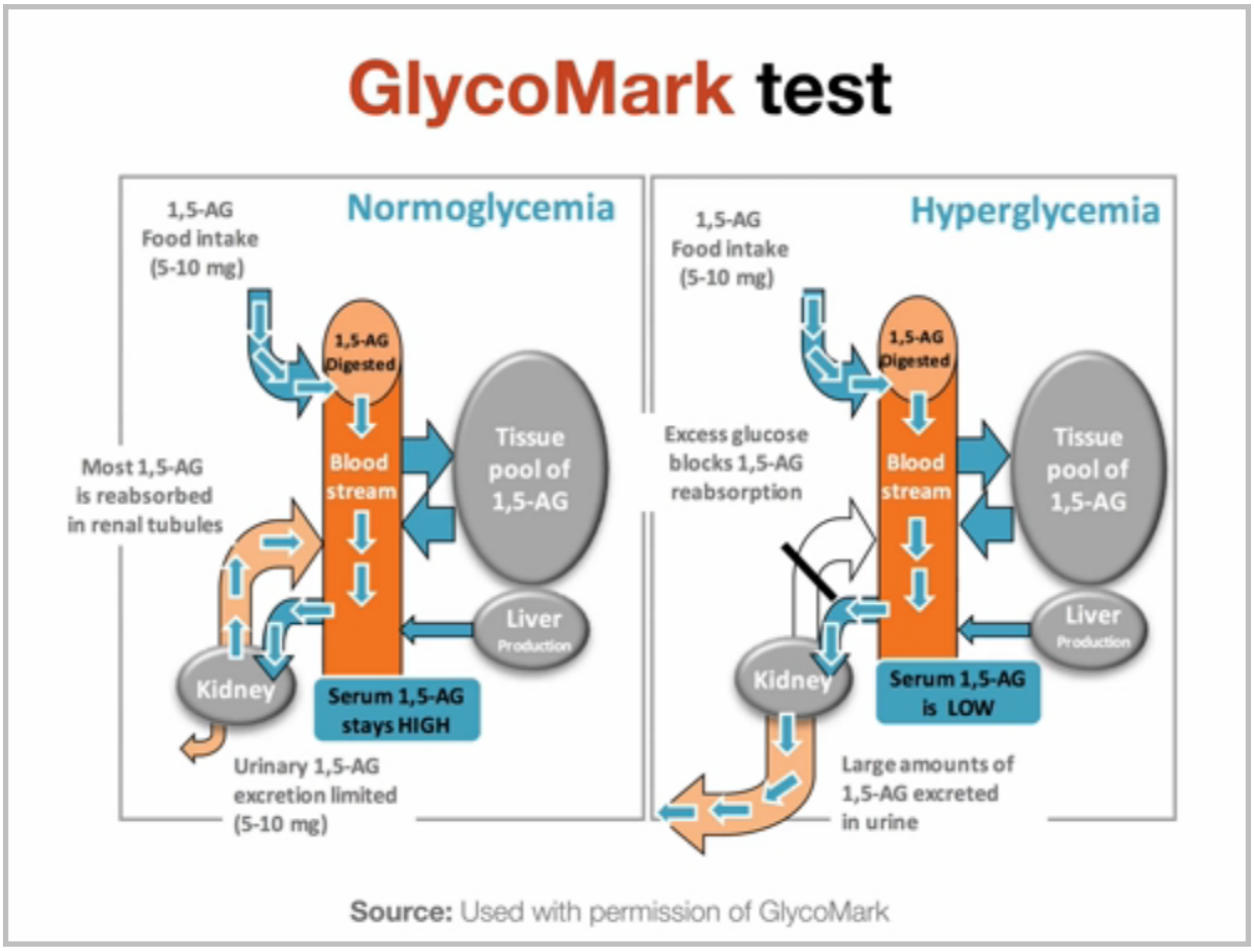
Another patient is a 47-year-old male. Chief complaint has been gas, bloating, occasional pain in the abdomen, acid reflux, and inconsistent bowel movements with loose stool. He recently moved here from China, and he eats a traditional Chinese diet with a lot of white rice. He was not aware of any blood sugar issues prior to coming to see me.

As you can see, the glucometer testing is fairly normal with a few exceptions. The fasting glucose was high on the first day and almost low on the last day. His 45-minute post-meal blood sugar on day two was 134, which is within the range but getting up there toward to the top. Then you can see on the last day his fasted reading right before lunch was 59, which is actually quite low.

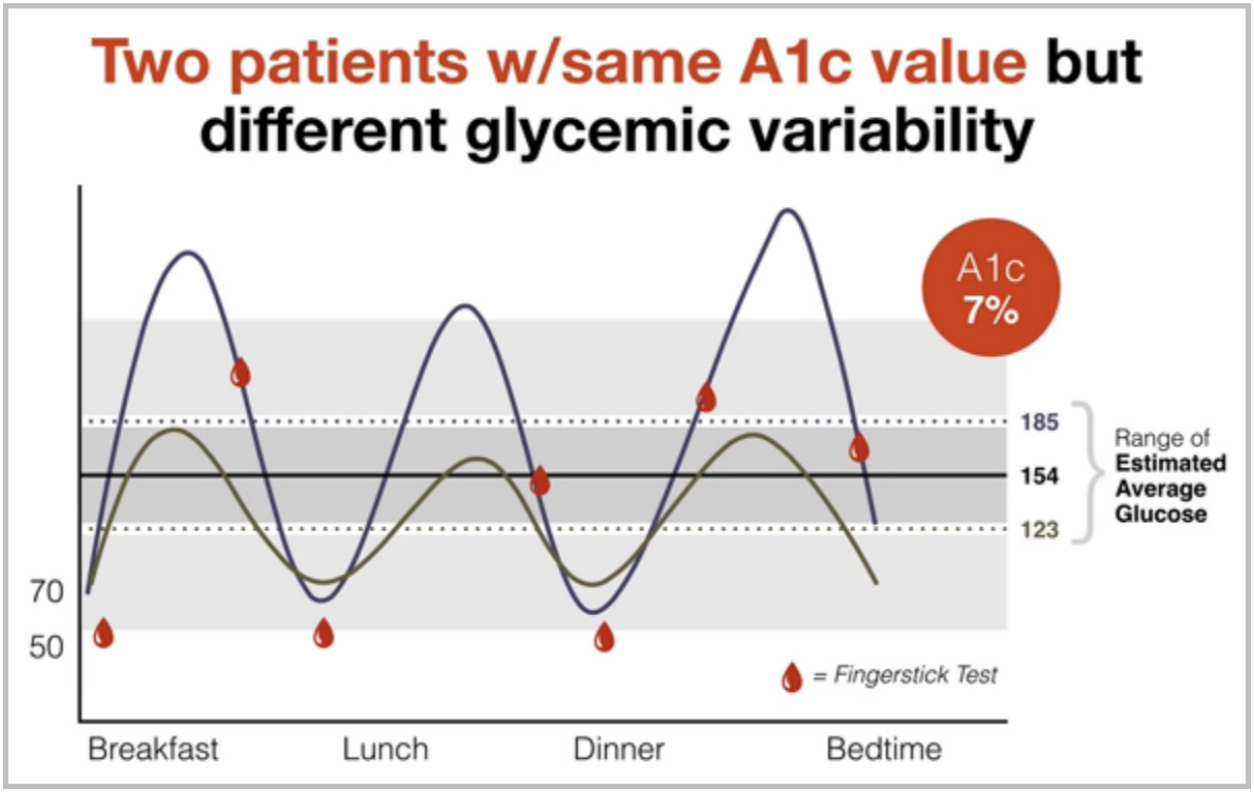
Marker	Value	Functional Range	Lab Range
Glucose	45	75 - 90	65 - 99
Hemoglobin A1c	6.0	4.4 – 5.4	4.8 - 5.6
Uric Acid	5.7	3.7 – 6.0	3.7 - 8.6
BUN	14	13 – 18	6 - 24
Creatinine	0.95	0.85 – 1.1	0.76 - 1.27
BUN/Creatinine Ratio	15	8 – 19	9 - 20
Sodium	145	135 – 140	134 - 144
Potassium	3.8	4.0 – 4.5	3.5 - 5.2
Chloride	102	100 – 106	97 - 108
C02	24	25 – 30	18 - 29
Calcium	8.8	9.2 – 10.1	8.7 - 10.2
Phosphorus	3.6	3.5 – 4.0	2.5 - 4.5
Magnesium	2.2	2.0 – 2.6	1.6 - 2.6
Protein, total	6.3	6.9 – 7.4	6.0 - 8.5
Albumin	4.3	4.0 – 5.0	3.5 - 5.5
Globulin	2.0	2.4 – 2.8	1.5 - 4.5
A/G ratio	2.2	1.5 – 2.0	1.1 - 2.5
Bilirubin, total	0.8	0.1 – 1.2	0.0 - 1.2
Alkaline Phosphatase	63	42 – 107	39 - 117
LDH	154	140 - 180	121 - 224
AST	16	10 - 30	0 - 40
ALT	20	10 - 29	0 - 44
GGT	19	0 - 40	0 - 65
TIBC	245	250 – 350	250 - 450
UIBC	134	150 - 375	150 - 375
Iron	111	85 – 135	40 - 155
Iron saturation	45	15 – 45	15 - 55
Ferritin	372	30 - 150	30 - 400
Cholesterol, total	127	150 - 240	100 - 199
Triglycerides	77	50 – 100	0 - 149
HDL	39	55 – 85	> 39
LDL	73	0 – 175	0 - 99
T. Chol / HDL Ratio	3.3	< 3	0 - 5.0
Triglycerides / HDL Ratio	1.97	< 2	
TSH	1.290	0.5 – 2.5	0.45 - 4.50
T4, total	6.1	6.0 – 12	4.5 - 12
T3 Uptake	34	30 - 38	24 - 39
T3, Total	103	100 – 180	71 - 180
Vitamin D, 25-hydroxy	29.1	35 - 60	30.0 - 100.0

Look at his other blood sugar results. His fasting glucose, according to just a normal draw, was 45, which is actually quite low, but his A1c is 6.0, which is high. He also had high iron levels; low HDL, which HDL is a marker for metabolic dysfunction, of course; high sodium, which can be indicative of

dehydration; and low vitamin D, which affects metabolic health. So this is a somewhat complicated presentation, but it's likely a reactive hypoglycemia type of situation. Again, on the spectrum progressing from normal blood sugar to full-fledged diabetes, that's kind of in the middle and moving over towards the right now, so this patient would require more prompt intervention.



The third option for getting an idea of post-meal blood sugar spikes is a test called GlycoMark. The GlycoMark test measures the 1,5-anhydroglucitol molecule in the blood. This provides a clinically proven one- to two-week measure related to the average daily maximum blood glucose. In people who don't have diabetes, and those with diabetes who have well-controlled blood sugar, 1,5-AG is stored at a steady state in the tissues and the bloodstream, which keeps blood levels of 1,5-AG high and produces a high GlycoMark score. In people with blood glucose spikes averaging over 180 mg/dL a day, 1,5-AG does not stay in the body as it should. As blood glucose rises, there is less 1,5-AG found in the blood as a result, so this is an inverse marker, where you see high 1,5-AG indicates normal or well-controlled blood sugar, and low 1,5-AG indicates high blood sugar.



This chart or graph illustrates why GlycoMark has some advantages over some other ways of measuring blood sugar. If you look at two patients here, hypothetical patients, they each have the same A1c value of 7 percent, but they have completely different glycemic variability. The blue line represents patient A, and that patient had really significant glucose excursions, which is what the technical term for blood sugar spikes is. You can see that patient had three really profound blood sugar spikes and then crashes after the spikes. The green line represents patient B who had some variability in his glucose, but it was more stable compared to patient A. It's impossible to know with hemoglobin A1c—you don't get this kind of information. It's all averaged out, so you don't see what the level of the spikes are. Research has shown, as I mentioned earlier with post-meal blood sugar, that the spikes are better predictors of cardiovascular disease and other complications, and they're more damaging than just an average higher blood sugar level.

Pros	Cons
Single blood draw	Can't provide info on timing/duration of ↑ glucose
More accurate than glucometer	Doesn't provide values for spikes
Doesn't require multiple finger sticks	Is affected by kidney/liver disease, malabsorption, pregnancy, and steroid use
No side effects (vs. 75 g glucose w/OGTT)	
Not affected by hemoglobinopathies	
Provides info on glycemic variability/spikes	

Results for GlycoMark have been proven in more than 40 clinical studies, but there are pros and cons like all of the other markers that we've talked about. The pros are that it could be obtained by a single blood draw. It's more accurate than a glucometer. It doesn't require multiple fingersticks or 75 g of glucose in the case of OGTT. It's not affected by hemoglobinopathies such as anemias or sickle cell disease because it's not a hemoglobin glycosylation marker like A1c is. It provides information on blood sugar spikes and glycemic variability.

However, it does have some cons. It can't provide information about the timing of high glucose levels or the duration of hyperglycemic episodes, i.e., whether they are occurring in a fasted state, a post-meal state, or both. It's affected by the presence of kidney disease; liver disease; malabsorption, which is probably fairly common in our patient population; pregnancy; and steroid use. So overall, I think GlycoMark can be a useful part of a blood sugar puzzle, but as with other blood sugar markers, it's not reliable on its own.

Interpreting GlycoMark is pretty simple. The higher the value, the better the blood sugar control. Values between 10 to 13 are ideal and correspond to an estimated average peak glucose of below 180 to 184. Keep in mind that we're talking about the overall population here, so they are looking at patients with severe type 2 diabetes as being abnormal, whereas we might look at patients with mildly elevated blood sugar as being abnormal. Values of 6 to 9 indicate what they call moderate blood sugar peaks throughout the day, corresponding to average peak glucose of 186 to 203. I'd say that's more than moderate, but anyway. Values below 5 suggest very high blood sugar spikes that correspond to average peak glucose of 212 to over 290, so that's full-blown type 2 diabetes with beta cell destruction.

Let's talk about a few other markers of metabolic dysfunction and dysglycemia. So the first is high triglycerides. Triglycerides are one of the major lipids found in the serum, and they're a major component of fat cells. Triglycerides are often elevated in conditions characterized by abnormal blood sugar such as obesity and type 2 diabetes. Another marker would be HDL or high-density lipoprotein, so-called good cholesterol. Low levels of HDL are observed in insulin resistance, obesity, and type 2 diabetes. The ratio of triglycerides to HDL is one of the best-studied markers of metabolic dysfunction. It should be below 2 optimally, although the lab range is 3.8. Then we have ALT, AST, and GGT, all enzymes that may be out of range in dysglycemic conditions. ALT and AST are amino transferases, and we're going to talk more about them later in the blood chemistry unit, but mild elevations can indicate nonalcoholic fatty liver disease.

GGT is an enzyme responsible for the extracellular catabolism of glutathione, and high GGT may be linked to increased oxidative stress and beta cell destruction. We'll be talking more about GGT

when we discuss iron overload. Many epidemiological studies have demonstrated high rates of elevated GGT among diabetic patients in the past 40 years.

Then we have uric acid. Epidemiological studies have also shown significant associations between increased uric acid concentrations and several components of the metabolic syndrome such as obesity, type 2 diabetes, hypertension, and also gout.

Marker	Value	Functional Range	Lab Range
Glucose	111	75 – 85	65 – 99
Hemoglobin Alc	6.3	4.4 – 5.4	4.8 – 5.6
Uric Acid	5.2	W: 3.2 – 5.5	2.5 - 7.1
BUN	21	13 – 18	6 – 24
Creatinine	0.63	0.85 – 1.1	0.57 – 1.00
Sodium	143	135 – 140	134 – 144
Potassium	4.3	4.0 – 4.5	3.5 – 5.2
Chloride	103	100 – 106	97 – 108
C02	25	25 – 30	18 - 29
Calcium	9.2	9.2 – 10.1	8.7 – 10.2
Phosphorus	3.4	3.5 – 4.0	2.5 – 4.5
Magnesium	2.0	2.0 – 2.5	1.6 – 2.6
Protein, total	7.0	6.9 – 7.4	6.0 – 8.5
Albumin	4.6	4.0 – 5.0	3.5 – 5.5
Globulin	2.4	2.4 – 2.8	1.5 – 4.5
A/G ratio	1.9	1.5 – 2.0	1.1 – 2.5
Bilirubin, total	0.3	0.1 – 1.2	0.0 - 1.2
Alkaline Phosphatase	106	42 – 107	39 - 117
LDH	133	140 - 180	0 – 214
AST	32	W: 10-30	0 – 40
ALT	51	W: 10-22	0 – 32
GGT	65	10 -26	0 -60
TIBC	373	250 – 350	250 – 450
UIBC	292	150 - 375	150 – 375
Iron	81	85 – 135	35– 155
Iron saturation	22	15 – 40	15 – 55
Ferritin	49	MW 33-263	15 - 150
Cholesterol, total	177	150 – 250	100 – 199
Triglycerides	161	50 – 100	0 – 149
HDL	43	55 – 85	> 39
LDL	102	0 – 175	0 – 99
Triglycerides / HDL Ratio	3.744	< 2	< 3.8
TSH	1.120	0.5 – 2.5	0.450 – 4.50
T4, total	8.8	6.0 – 12	4.5 – 12.0
T3 Uptake	27	W: 28-35	24 – 39
T3, Total	113	100 – 180	71 – 180
Vitamin D, 25-hydroxy	27.5	35 - 60	30.0 - 100.0
WBC	6.2	5.0 – 8.0	3.4 - 10.8
RBC	4.36	4.4 – 4.9	3.77 - 5.28
Hemoglobin	13.3	W: 13.5-14.5	11.1 - 15.9

The lab result on this slide is from a 59-year-old female with type 2 diabetes. We saw this one before. Notice her high triglycerides; her low HDL in the functional range at least; her high triglyceride-to-HDL ratio, again not out of the lab range but out of what I consider to be optimal; her high ALT and GGT, both out of the reference range; and then her AST is elevated in the functional range. She has lab-low vitamin D and then, of course, the abnormal fasting glucose and A1c.

So, as I mentioned before, there are a lot of advanced markers that you can order that are indicative of blood sugar dysregulation.

	Laboratory Test	Notes	High Risk	Intermediate Risk	Optimal	High Risk Range	Intermediate Risk Range	Optimal Range	Previous Results
Glycemic Control	Glucose (mg/dL)				90	> 125	100-125	70 - 99	
	HbA1c (%)			5.7		≥ 6.5	5.7 - 6.4	≤ 5.6	
	Estimated Average Glucose (mg/dL) (calculated)			116.9		≥ 139.9	116.9 - 139.8	≤ 116.8	
	Fructosamine (µmol/L)			327		> 346	302 - 346	< 302	
	Glycation Gap				-1.63	> 0.77	0.45 - 0.77	< 0.45	
	Postprandial Glucose Index		13.7			> 7.9	6.0 - 7.9	< 6.0	
Insulin Resistance	Leptin (ng/mL)			21		> 43	20 - 43	< 20	
	Leptin:BMI Ratio			0.88		> 1.17	0.66 - 1.17	< 0.66	
	Adiponectin (µg/mL)				21	< 10	10 - 14	> 14	
	Free Fatty Acid (mmol/L)				0.15	> 0.70	0.60 - 0.70	< 0.60	
	Ferritin (ng/mL) *				60	> 108	61 - 108	< 61	
	α-hydroxybutyrate (µg/mL)§				4.3	> 5.7	4.5 - 5.7	< 4.5	
	Oleic Acid (µg/mL)§				22	> 79	60 - 79	< 60	
	Linoleoyl-GPC (µg/mL)§				30.0	< 10.5	10.5 - 13.0	> 13.0	
	IR_i Score (calculated)				18.1	< 8.0	8.0 - 10.0	> 10.0	
	HOMA-IR (calculated)				0.8	> 4.2	2.6 - 4.2	< 2.6	
Beta Cell Function	Insulin (µU/mL)				4	≥ 12	10 - 11	3 - 9	
	Proinsulin (pmol/L)				5	> 16	8 - 16	< 8	
	C-peptide (ng/mL)				1.3	> 4.6	3.1 - 4.6	1.0 - 3.0	
	Proinsulin:C-peptide Ratio			3.7		> 4.9	3.6 - 4.9	< 3.6	
	Anti-GAD (IU/mL)				< 5	> 5 Positive		≤ 5 Negative	

True Health Diagnostics* has a diabetes prevention and management panel, or DPMP, with many of these markers that I really like. It includes a lot of the basic markers we've discussed, but it also includes things such as glycation gap, postprandial glucose index, leptin, adiponectin, free fatty acids, ferritin, alpha-hydroxybutyrate, oleic acid, linoleoyl GPC, insulin resistance score, HOMA-IR, insulin, proinsulin, C-peptide, anti-GAD antibodies, glutamic acid decarboxylase, and then several ratios that are comprised of these markers. It can be helpful if the basic markers are equivocal, or if you have a patient with known impaired glucose tolerance or dysglycemia. You can also use this test to track the progression and track the success of your treatment. This test can also help determine whether beta cell destruction has occurred because it has a full category of markers that are indicative of beta cell function, and that can help you guide the treatment plan.

Okay. That's it for part one of the hyperglycemia presentation. In part two, we're going to finish up the discussion of markers and diagnosis, and then we're going to move on to treatment. See you then.

* **Note:** True Health Diagnostics is no longer in business. See **this post** for the latest updates.