GLYCOSYLATED HEMOGLOBIN (HBA1C) AND DIABETES

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Hemoglobin A1c was first separated from other types of hemoglobin by Huisman and Meyering in 1958. It was first noted to be associated with diabetes in 1969 by Samuel Rahbar and coworkers. It was not until 1976 that Koenig and coworkers proposed using the HbA1c values for monitoring the degree of control of glucose metabolism in diabetic patients.

These findings were significant because it gives the health care provider an additional tool with which to evaluate their patients. The Diabetes Control and Complications Trial (DCCT) demonstrated that people with diabetes who maintained fasting serum glucose levels and HbA1c levels at or close to a normal range decreased their risk of complications such as heart disease, blindness, nerve damage and kidney damage by 50-75%. Based on results of this study, the American Diabetes Association recommends routine glycosylated hemoglobin testing to measure long-term control of blood sugar.

Glucose that is not used for energy is left in the blood, where it attaches itself to the hemoglobin by glycosylation (discussed later). Once a hemoglobin molecule is glycated (glycosylated), it remains that way. This excess glucose will be in the red blood cell for the lifespan of the red blood cell, approximately 120 days. The higher the serum glucose level, the higher the percent of glucose that is stored in hemoglobin, thus HbA1c would increase as the long-term (120 days) average blood glucose level was elevated. Another way of saying it is, the higher the HbA1c value, the higher the average serum glucose level has been over the past 120 days or so.

A 1% change in an HbA1c result reflects a change of about 30 mg/dl (1.67 mmol/L) in average serum glucose. As an example, an HbA1c of 6% would correspond roughly to an average serum glucose value of 135 mg/dl (6.7 mmol/L). On the other hand, a HbA1c of 10% would correspond roughly to an average serum glucose value of 275 mg/dL(13.3 mmol/L). One would further interpret this by saying, in the case of the 10% HbA1c value, that the patient's serum glucose has been averaging roughly 275 mg/dl (13.5 mmol/L) for the last 120 days or so. The following table can be used as a guide for comparison of HbA1c levels and corresponding serum glucose levels :

HbA1c(%)	Avg. Blood Sugar (mmol/L)	(mg/dL)
4	3.3	65
5	5.2	100
6	6.7	135
7	8.3	170
8	10.0	205
9	11.7	240
10	13.3	275
11	15.0	310
12	16.7	345
13	18.3	380
14	20.00	415

Laboratory results may differ depending on the analytical technique (electrophoresis, chromatography, immunoassay), the age of the subject, and biological variation among individuals. Two individuals with the same average blood sugar can have A1c values that differ by as much as 1 percentage point. In general, the normal reference range (that found in healthy persons), is about 4%-5.5%

The HbA1c will not reflect temporary (real time) acute changes in blood glucose level. That's why the health care provider will order a "STAT glucose". If, on the other hand, the health care provider wants to know the chronic mean serum glucose value over the past few weeks to months they will order the HbA1c. Glycosylated hemoglobin is recommended for both (a) checking blood sugar control in people who might be pre-diabetic and (b) monitoring blood sugar control in patients with more elevated levels, as in frank diabetes. For a single blood sample, it provides far more revealing information on glycemic behavior than a fasting blood sugar value.

American Diabetes Association guidelines are similar to others in advising that the HbA1c test be performed at least two to three times a year in patients with diabetes who are meeting treatment goals and quarterly in patients with diabetes whose therapy has changed or who are not meeting glycemic goals.

As with all laboratory tests, other conditions might affect the results of the test, and the HbA1c is no different. Patients with recent blood loss or hemolytic anemia, or genetic differences in the hemoglobin molecule (hemoglobinopathies) such

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bling block along what continues, to this day, to be the rocky road to effective program assessment. My twenty-year retrospective of outcomes assessment in Respiratory Care brings me to wonder just how far we've actually come.

Where and how students "end up" does matter a lot. We have a responsibility to them and to our public. In concept, outcomes assessment is, without a doubt, the "right" thing to do. And we all do it. Not, I hope, just because of the external mandate of CoARC, but because we are accountable to all of our stakeholders and because we want to effect overall programmatic improvement.

Yes, educators will always grumble about busy work and bureaucratic intrusion, but the educators I know really do believe in the concept of goal-oriented outcomes assessment. None are unwilling to do any productive work involved. Nor do they resist being held accountable. On the contrary, they actually welcome the opportunity for meaningful program information that can be applied in their particular community of interest. They all willingly invest extensive time and energy, precious resources which many educators feel might be better spent doing rather than assessing and reporting. Sometimes, what is meant to improve the quality of our efforts may be standing in the way of real effectiveness.

What gets lost in the sauce is the fact that outcomes assessment is not an end in itself, but rather a means to an end. So why not more emphasis on curricula, teaching, learning, or the kinds of student activities that lead to better outcomes?

The road to effective and useful outcomes assessment in RC education has been lined with stepping stones and stumbling blocks. I'm not sure where the road is actually taking the profession, but I believe we'll know it when we arrive. We're not there yet.

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as sickle cell disease, Hb F or S, and other conditions, are not suitable for this test. An alternative fructosamine test may be used in these circumstances and it similarly reflects an average of blood glucose leves over the preceding 2-3 weeks.

It is interesting to take a short look at how this glycosylation process works in the hemoglobin molecule. A glycosylated hemoglobin is formed spontaneously in red blood cells by the combination of the NH2-terminal amino groups of the hemoglobin beta chain and glucose. The aldehyde group of the glucose first forms a Schiff base with the NH2-terminal amino group, which then rearranges to a more stable amino ketone linkage by a spontaneous (nonenzymatic) reaction known as the Amadori rearrangement. The higher the blood concentration of glucose and the longer the duration of the hyperglycemia, the more HbA1c will be formed (greater percent of glucose that becomes bound to hemoglobin).

The utility of this laboratory test to the respiratory therapist? Diabetic patients can be problematic very quickly if there is a sudden change in glucose level. If your patient has an HbA1c result on their chart, and if it is elevated above 6%, it will be worth your while to take extra precaution. Your patient has a recent (last 2 weeks to three months or so) history of elevated blood glucose levels.

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