Diabetes: Important Considerations for Anesthesia Technologists/ Technicians

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ABSTRACT

In this article we will discuss some implications that present themselves when patients with certain types of diabetes need anesthesia care. We will mention several types of diabetes, i.e.: mellitus, insipidus, and gestational. However, our focus will dwell on type 2; but we will briefly discuss other types[1]. We will briefly speak about how they are different or the same. Certainly, we will dwell and discuss the need for POC testing, drug considerations and other concerns may indicate the involvement of an anesthesia technologist or technician. We will also examine some indications and contraindications that anesthesia care providers consider during the perioperative period for these patients with surgical needs and the coexisting diabetes in certain surgical procedures and events. Finally, we will speak about how the anesthesia care team would benefit from the involvement of the anesthesia technologist/ technician in these cases within the scope of the anesthesia technologists/ technicians.

Keywords: Diabetes, anesthesia, anesthesia technologist, anesthesia technician.

DIABETES: IMPORTANT CONSIDERATIONS

Diabetes is a medical condition that was first described in medical texts in 1500 B.C., by Egyptian physicians (McCoy, 2009) Since that time, the Greeks, Indic peoples, Chinese, and other have all identified aspects of the disease. Many of these descriptions coincide with the major observed effects of specifically diabetes mellitus which include

increased thirst (polydipsia), dry mouth, frequent urination (polyuria), fatigue, blurred vision, weight loss. slow-healing sores or cuts, and numbness or tingling in the hands or feet (Lakhtakia, 2013). Indeed, there are metabolic issues which we will discuss later that are relevant to diabetes and anesthesia. Suffice it to say for now that diabetes is a problematic issue for the anesthesia care team.

Over the last one hundred years, we have seen an incredible jump in our understanding of the endocrine system, the effects of diabetes on the body, and the implications of anesthesia care for these patients. We can begin with having a basic understanding of what occurs in a couple of types of diabetes physiologically. There is more than one type of diabetes. The most common is Type 2; however, we will briefly mention Prediabetes, Type 1, Gestational, and Type 3c.

DIABETES MELLITUS

Again, the most common is Type 2 Diabetes with 90% of all diabetic patients affected being pf this type (Hines, 2017, p. 450). With Type 2, the body does not make enough insulin and/or the patient's cells do not respond as usual to insulin produced in the pancreas. This diminished action of insulin is frequently referred to as insulin resistance. It primarily affects people older than 35 years of age who are overweight[2]. Notwithstanding, over the last ten to fifteen years more young adults and children have been diagnosed with Type 2 in the United States (Hines, 2017).

Indeed, diabetes types are not a progressive nomenclature of the disease process. It is not like you move from one to the next, as if graduating from one "level" then to the next. Indeed, the only type which has a direct correlation to any another type is Prediabetes. It is a direct forerunner of Type 2. Blood glucose levels in prediabetic patients are higher than normal but are often not high enough to be officially diagnosed with Type 2 diabetes. Often, this fact gives way to complacency in patients, and unfortunately allows for Type 2 diabetes to fully germinate. Once a patient exceeds the upper fasting glucose limit of 100mg/dL further testing is advised (Hines, 2017, p. 451). Often the measured lab value of choice is HbA1c (most often referred to as A1C). The HbA1c test offers an effective tool to measure long-term blood sugar level and whether adequate control exists. The percentage value is a derived value from laboratory testing and indicates how much hemoglobin is interacting in glucose as a percentage. Certainly, the values reflect the proportional interactions of hemoglobin as it relates to the average plasma glucose concentration during the preceding 60–90 days in that patient's blood.

Hemoglobin is glycated by glucose and other sugars in blood. We will not delve into that aspect of diabetes as it is not within the scope of this article. However, glycation plays an important part in diabetes, aging, and other chronic diseases as demonstrated in research literature (Lima, 2013 and Scheper, 2023). Suffice it to say that there is a correlation to inflammatory response which we will discuss later.

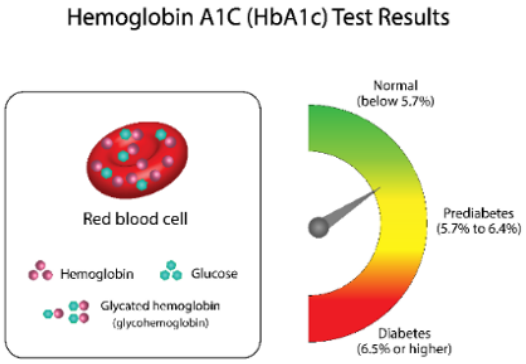

Figure 1 *- Glycation and normal HbA1c values.*

Nevertheless, for clinical decisions the anesthesia care providers use general guidelines that indicate what the normal ranges are for A1C levels. In general, a level of 5.7% or less is desirable and is considered normal. Levels between 5.7% and 6.4% are considered Prediabetic, and all levels greater than 6.5% are clinical diabetes. With the higher values, "an increased risk of microvascular and macrovascular disease begins when the HbA1c proportion is 6.5% or higher" (Hines, 2017, p. 451). Monitoring of HbA1c is recommended at least twice a year for prediabetics or with greater frequency (every 3 months) if control of blood sugar levels is ineffective or if therapy has been altered. For anesthesia care providers, this concept of testing becomes important at the bedside as the values obtained at the bedside will guide the providers in clinical judgements, decisions, and care strategies.

Briefly, we will mention that Type 1 diabetes is rarer with only 5% to 10% of the population affected. It is an autoimmune disorder. It usually affects infants or young children. In fact, it is a common childhood disease. It usually will affect patients before the age of forty (40) but could develop at any time during early life. The usual course of Type 1 is different than what we have discussed above. The patient's immune system attacks and destroys insulin-producing cells in the pancreas for unknown or poorly understood reasons (Hines, 2017). It is theorized that environmental triggers such as enteroviruses, dietary proteins, drugs/chemicals may trigger the body's

aggressive autoimmune response in genetically susceptible individuals. Often, Type 1 patients may present with partial or full-on ketoacidosis which indicates severe insulin deficiency and unrestricted lipolysis.

The CDC defines ketoacidosis as a serious complication for both Type 1 and Type 2 diabetes. (CDC, 2022). The body does not have enough insulin. In turn, this low insulin level limits absorption of blood sugar into cells for use as energy. Rather, the liver begins to break down fat for energy (lipolysis). It is during this phase of the process that acids (also called ketones) are produced. As rapid ketones production ramps up in the liver, it begins to accumulate in blood. This is a serious threat to the patient's life because it changes the pH balance in blood which will cause metabolic acidosis. If this metabolic problem is not addressed and treated it will inevitably lead to serious morbidity (complications) and mortality (death) for the patient.

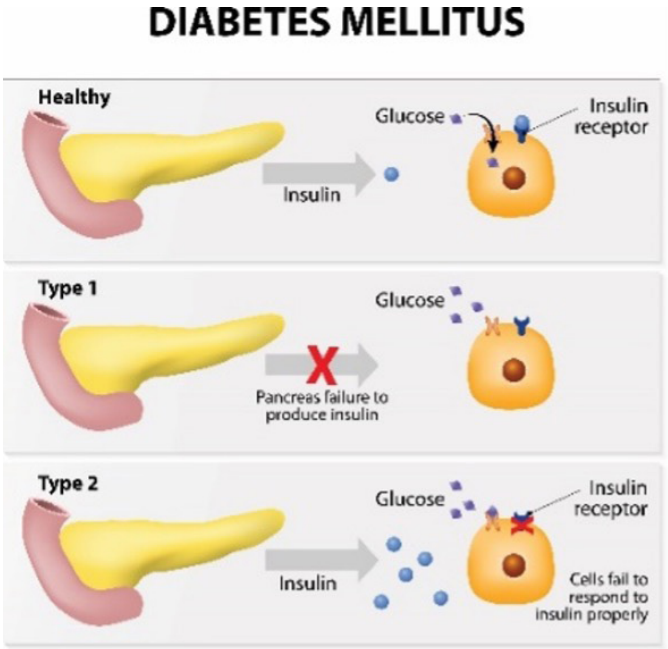

Figure 2 *- Diabetes Mellitus*

I will only glancingly mention Gestational diabetes here. This type of diabetes develops during pregnancy in some patients. The positive aspect (if any) of Gestational diabetes is that it usually goes away after pregnancy. Yet, if a patient is diagnosed with gestational diabetes, they are at a higher risk of developing Type 2 diabetes later in life.

Briefly, Type 3c diabetes happens when your pancreas experiences some type of physical or chemical trauma which affects the production of insulin. Also, diseases or conditions like pancreatitis, pancreatic cancer, hemochromatosis, and cystic fibrosis may damage the pancreas and its ability to produce insulin. Furthermore, procedures where the pancreas is partially removed (Whipple or Frey procedures) or a total pancreatectomy will result in Type 3c diabetes (McCoy, 2009).

Common to all these types is the function of insulin as it relates to cells in the human body or too much within blood. All these various medications can help reduce complications and will aid a return to a semblance of homeostasis. From insulin, to glipizide, metformin, pioglitazone, and acarbose; all of which are used to maintain glucose levels between 90-130 mg/dL, and an A1C below 7% (Hines, 2017). However, most if not all these drugs are not effective forever. As with any medication, these drugs all come with positive and negative side effects which sometimes need to be dealt with intraoperatively by the anesthesia care team.

CONCOMITANT DIFFICULTIES

Above, I have already mentioned diabetes-related ketoacidosis (DKA). To reiterate, in DKA the body does not have enough insulin by which the body can gather energy and because it cannot draw it from blood glucose it will alternatively to lipolysis. This is not ideal as the body begins to store ketones in the blood which produces a metabolic acidosis which can lead to other imbalances and death. Hines describes it as a common occurrence with diabetic patients:

> in patients with type 1 diabetes and are precipitated by infection or acute illness. High glucose levels exceed the threshold for renal tubular absorption, which creates a significant osmotic diuresis with marked hypovolemia.... [producing s]ubstantial deficits of water, potassium, and phosphorus (p. 455)

However, despite laboratory values of electrolytes presenting as normal or increased the likelihood of hyponatremia is high. It usually results from the effect of hyperglycemia and hyperosmolarity on water distribution in the body. The deficit of potassium is important as it can directly affect myocardial function. Also, HHS can create a deficit of phosphorus which can lead to diaphragmatic and skeletal muscle dysfunction and impaired myocardial contractility. During DKA, blood gases are a useful tool. Additionally, electrolyte panels and blood glucose testing would be of significance as diabetics are often dealing with electrolyte imbalances due to potential dehydration. One more important value is sodium levels. Hyponatremia, as mentioned above, is related to high blood sugar levels. High sugar levels without correcting low sodium levels can lead to cerebral edema. A significant

infusion of normal saline and insulin must be conducted as soon as possible. Of note, DKA is more strongly associated with Type 1, but it is very probable with unmanaged or poorly managed Type 2 diabetics.

Interestingly, this leads to another problem which is more often associated with Type 2 referred to as Hyperglycemic Hyperosmolar Syndrome (HHS). It is most often associated with patients older than 60 years of age who have other significant co-existing diseases, i.e., infections, MI, pneumonia, etc. (Hines, 2017, p. 455). Treatment involves fluids resuscitation with normal saline, electrolyte replacement, and glycemic control. Although similar, DKA and HHS affect the body in separate ways. Importantly, DKA is much more acute and problematic than HHS. Nonetheless, HHS may take several days or weeks to develop, but if untreated will result in death. The main difference between DKA and HHS is that DKA involves ketones and blood acidity; HHS does not. The two complications have similar symptoms, including intense thirst, frequent urination, and mental status changes.

There are more concerns with Type 2 diabetics which should be mentioned here. Macro and microvascular dysfunction, nephropathy, neuropathy, and retinopathy are all major considerations during anesthesia care. Aggressive glycemic control is important perioperatively. However, especial emphasis is made on the intraoperative period according to Wall (Hines, 2017, p. 457). Indeed, the literature reveals a significant correlation between perioperative hyperglycemia and negative clinical consequences.

INTRAOPERATIVE MANAGEMENT

It comes to what can our role do to help eliminate or reduce part of the risks, from an anesthesia perspective. The anesthesia technologist or technician can and should assist the care providers in the delivery of the chosen care plan. Among the actions of the anesthesia technologist or technician, is to conduct testing of serum glucose levels. Often, the patient requires frequent point of care (POC) tests. Most guidelines recommend that glucose should be monitored at least every hour and even every 30 minutes in patients undergoing coronary artery bypass surgery or patients with high insulin requirements (Hines, 2017, pg. 457). During initial testing for diabetes urine glucose is often used. Nevertheless, it is an unreliable test which could easily be replaced with a venous blood test. In fact, the literature recommends that glucose labs are collected from a venous plasma or serum sample. Albeit the widespread practice is that blood samples are gathered from an arterial line, especially if a patient is going to have multiple tests. However, Dr. Russell Wall III relays that "arterial and capillary blood yields glucose values approximately 7% higher than those for venous blood, and whole-blood determinations are usually 15% lower than plasma or serum values" (Hines, 2017). The anesthesia care teams should aim to avoid both hyperglycemia and hypoglycemia. Yet, it is especially important to avoid hypoglycemia because recognition of hypoglycemia is sometimes delayed in anesthetized, sedated, or patients on pain control medications. Furthermore, patients with autonomic neuropathy caused by diabetes, or who have been prescribed β-blockers (i.e., atenolol, labetalol), or sympatholytics (i.e., moxonidine, clonidine) may also have delayed recognition of symptoms. Therefore, it is imperative that POC testing be done on a regular basis. Hypoglycemia in surgical patients is often addressed with an injection of 50 mL of 50% dextrose in water, which will raise the glucose level to an acceptable level.

Similarly, hyperglycemia may also need to be dealt with swiftly. Surely, the choice is to quickly being an infusion of insulin. If it is a scheduled case, then therapy should begin prior to surgical incision by at least 2 hours and with the guidance of a glucometer levels should be maintained between 120 and 180 mg/dL intraoperatively. Indeed, if the glucose level rises above 200 mg/dL it is likely to cause glucose excretion in urine and dehydration. Additionally, high glucose levels will impair wound healing. Normally, one (1) unit of insulin will lower glucose levels by 25-30 mg/dL. Yet, insulin needs are greater for patients undergoing coronary artery bypass graft surgery, patients on steroids, patients with severe infections, and patients receiving hyperalimentation or vasopressor infusions (Hines, 2017 p.457). However, the difficulty does not stay with complicated cardiac cases or with the critically ill. Many patients with diabetes have complications related to hyperglycemia even though their surgery was less complicated and uneventful (Frisch, 2010). Indeed, danger exists as blood glucose levels become too low, and insulin infusions could significantly intensify hypoglycemia. Best practice guidelines indicate that insulin therapy in the intraoperative period should include an "infusion of 5% dextrose in half-normal saline with 20 mEq of potassium chloride at 100–150 mL/h to provide enough carbohydrate" to reduce hepatic glucose production and lipolysis.

Importantly, another potential path for abnormally high glucose levels is surgical stress and anesthesia itself

(Duggan, 2017). Inflammatory response is correlated with hyperglycemia per Duggan et al., the literature suggests that this inflammatory response increases the morbidity and mortality for diabetic patients (Scheper, 2023). In fact, elevated blood glucose levels impair white blood cell function and cause an "overproduction of reactive oxygen species, free fatty acids (FFA), and inflammatory mediators"[3] (Duggan, 2017). Pathophysiologic changes like these contribute to direct cellular damage, vascular injury, and immune dysfunctions. This is significant because perioperative hyperglycemia is present in 20 to 40% of patients that go through a surgical event. According to Duggan et al., this hyperglycemic stress response correlates with significant perioperative complications. Much of the research encompasses cardiac and neurosurgery; however, most other specialty surgical interventions seem not to fare any better. Indeed, a change of "20mg/dL (1.1mM) above 100 mg/dL (5.5mM), there was a 30% increase" in complications including renal, pulmonary, and death in one study. In another study, a powerful correlation was found among hyperglycemic patients. The risk of infection, atrial fibrillation, heart failure, myocardial infarction, pericarditis, neurologic complications, and pulmonary complications were all greater if hyperglycemia was present intraoperatively (Duggan, 2017 p.549). Consequently, Duggan et al., advocate for the use of point-of-care testing (POC). Although the main laboratory tests will provide the most accurate blood glucose measurements, the turnaround times are problematic for the pace of surgical events and the decisions anesthesia care providers must make. The rapid results provided by POC glucometer devices enable the anesthesia care providers to proceed with deliberate decision making to treat labile glucose levels. Notwithstanding, anesthesiologists must recognize the limitations of glucometer POC testing. A decade ago, the Food and Drug Administration issued guidance outlining that most all POC readings greater than 70 mg/dL be within 10% of what the main laboratory reference values are and that all BG readings less than 70 mg/dl be within 7 mg/dl (0.39 mM). Sadly, glucometers in an unclear number of hospitals "do not meet these recommended metrics and may be less accurate than providers recognize" (Duggan, 2017, p. 557). It is within the scope of practice of anesthesia technologists and technicians to maintain these devices, perform Q&A tests, and to report discrepancies or errors to the main lab. As it stands, these POC devices are being highly scrutinized for their accuracy. It behooves our providers and our patients to maintain these devices in optimal readiness as these machines are continually evaluated for their accuracy. Indeed, the anesthesia care team is dependent on these machines' ability to render accurate results that will guide critical clinical decisions for diabetic patients.

POSTOPERATIVE CARE

In the postoperative period, management of diabetic patients requires further effort in accurate monitoring of insulin requirements. As discussed, POC testing is key. The anesthesia technologist or technician often is not involved in the discharge and postoperative care of patients. Although hyperglycemic and hypoglycemic events are possible in the post anesthesia care unit, there are no optimal blood glucose level targets which have been established or adopted universally for the perioperative period (Duggan, 2017). Yet, the currently the American Diabetes Association (ADA) recommends a target blood glucose range of 80 to 180 mg/dL in the perioperative period and 140 to 180 mg/dL for critically ill patients. On the other hand, the American Association of Clinical Endocrinology has a consensus statement about diabetes management in general which can be useful (Samson, 2023). Yet, this topic expands to postoperative infections associated with hyperglycemia and is discussed by various researchers (Frisch, 2010). Indeed, practitioners encounter and render care for these diabetic patients during postoperative care within the hospital. It is crucial that the anesthesia technologist or technician participate in increasing the accuracy of testing, help minimize errors, aid in enhancing monitoring, and help improve treatment for this vulnerable population of patients.

CONCLUSION

Please note that the goal of the anesthesia care team is to enhance the outcome for the patient. The anesthesia technologist is responsible for proving the appropriate POC testing, which includes operation of the POC testing equipment, i.e., glucometer, arterial blood gases, providing proper intravenous fluids, and stocking the correct medications for administration (American Society of Anesthesia Technologists and Technicians, Scope of Practice, 2023)[4]. The goal for anesthesia technologists and technicians is to aid in the delivery of safe and meticulous care.

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Footnotes

1. Note about the Cleveland Clinic website. **https://my.clevelandclinic.org/health/diseases/7104-diabetes is a treasure trove of information. I highly recommend that you visit it. It has nicely broken-down explanations of various important concepts as it relates to diabetes.**

2. Some key factors that go beyond age and weight are genetic in nature. Often diabetes affects specific ethnicities with varying degrees of intensity and associated co-morbidities like heart disease, obesity, obstructive sleep apnea, kidney failure, etc. Indeed, genetic predispositions affect many patients beyond diabetes. Thus, it is an important consideration for anesthesia care providers, and by extension for the anesthesia care team.

3. Reactive oxygen species are a type of unstable reactive molecule that contains oxygen. It will easily react with other molecules in a cell's biological process. Buildup of reactive oxygen species in cells can cause damage to DNA, RNA, and proteins, and eventually cellular death. These reactive oxygen species are often referred to as free radicals. Read more here: **https://www.cancer.gov/publications/dictionaries/cancer-terms/def/reactive-oxygen-species**

4. It is important to point to the 2023 revised ASATT Scope of Practice, because as the society moves forward its inclusion and its application to various situations will become an invaluable tool in advocating for the technologists' and technicians' practice.

Take the QUIZ *on the next page!*

Continuing Education Quiz

To test your knowledge on this issue's article, provide correct answers to the following questions on the form below. Follow the instructions carefully.

1. **Which type of diabetes is the most common?**
   A) Insipidus
   B) Gestational
   C) Juvenile
   D) Mellitus

2. **A common symptom of Type 2 diabetes is _____ .**
   A) decreased thirst.
   B) weight gain.
   C) frequent urination.
   D) hypersalivation.

3. **A(n) _____ glucose test is best to determine blood sugar levels for the past 60 to 90 days.**
   A) HbA1C
   B) Postprandial
   C) Fasting
   D) CBC

4. **Ketoacidosis is a complication for both Type 1 and Type 2 diabetes that occurs because _____ .**
   A) excess insulin is present in blood
   B) the pH is too high.
   C) there is not enough insulin in blood.
   D) CO2 is too low.

5. **If ketoacidosis is present, what does the body do to generate an energy source for cells? The body _____.**
   A) begins to break down muscle.
   B) resorts to lipolysis.
   C) releases sodium bicarbonate from the liver.
   D) vasoconstricts to reduce metabolism.

6. **With both Type 1 and Type 2 diabetes, a major consequence of diuresis, ketoacidosis and hyperglycemia on blood chemistry is?**
   A) Electrolyte imbalances
   B) Low hemoglobin
   C) Metabolic alkalosis
   D) Methemoglobinemia

7. **A major complication that sometimes follows insulin administration is _____.**
   A) Hypercalcemia
   B) Hypoglycemia
   C) Hypokalemia
   D) Hypernatremia

8. **Which of the following may cause abnormally high glucose levels in surgical patients?**
   A) Metformin and glipizide.
   B) Insulin and Reactive oxygen.
   C) Stress and anesthesia.
   D) Normal saline and Ringer's lactate.

9. **True or false**
   All glucometers produce extremely accurate results.

10. **The American Diabetes Association recommends a target blood glucose level for non-critically ill patients to be between _____ mg/dL.**
    A) 40-120
    B) 80-180
    C) 140-220
    D) 180-260

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The answers to the Spring 2024 "Diabetes: Important Considerations for Anesthesia Technologists/Technicians" Quiz 1 are: (circle answers)

1.	A B C D		6.	A B C D	
2.	A B C D		7.	A B C D	
3.	A B C D		8.	A B C D	
4.	A B C D		9.	T F	
5.	A B C D		10.	A B C D	

Quiz 1

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