Hypoglycemia in T1D

**Question 1**

**Correct Answer:** E. Altered mental status and the need for assistance

**Answer Rationale:**
A joint position statement from the American Diabetes Association and the European Association for the Study of Diabetes supported the work of the International Hypoglycemia Study Group to develop new definitions of hypoglycemia (Diabetes Care and Diabetologia, January 2017). Subsequently, a consensus report was published in Diabetes Care (December 2017) and was endorsed by a range of leadership societies.

Level 1 hypoglycemia is defined by a blood glucose value below 70 mg/dL (<3.9 mmol/L) (Answer A), but at or above 54 mg/dL (≥3.0 mmol/L). Most patients with glucose levels in this range are asymptomatic, although documentation of glucose values in this range should serve to alert providers that a patient is at higher risk for more significant hypoglycemia. Level 2 hypoglycemia includes documentation of a blood glucose value below 54 mg/dL (<3.0 mmol/L) (Answer B) with altered cognition and the potential for serious sequelae. Repeated episodes of level 2 hypoglycemia are associated with reduced counterregulatory function and predict increased risk for cardiac arrhythmias and mortality. Level 3 hypoglycemia (severe hypoglycemia) is defined as hypoglycemia requiring assistance to restore euglycemia and includes altered mental status and risk of coma (Answer E). While a blood glucose value below 40 mg/dL (<2.2 mmol/L) may well be associated with altered mental status and the need for assistance, some patients with hypoglycemic unawareness and/or frequent hypoglycemia may not experience adrenergic symptoms at this level and remain asymptomatic (thus, Answers C and D are incorrect).

**Educational Objective:**
Categorize hypoglycemia and recognize the importance of associated cognitive impairment.

**Reference(s):**

Question 2

Correct Answer: B. Increased all-cause mortality

Answer Rationale:
A number of important sequelae are linked to episodes of severe hypoglycemia. Specifically, adverse cardiovascular outcomes and all-cause mortality (Answer B) have been associated with repeated severe hypoglycemic excursions. While there are most likely a number of important changes in the vascular system, prolongation of the QTc interval (rather than reduced QTc interval [Answer A]) could predispose a patient to cardiac arrhythmia, and there is an enhancement in coagulation capacity (platelet activation) (rather than reduced platelet adherence and increased risk of hemorrhage [Answer E]) such that inappropriate thrombosis could contribute to cardiac dysfunction.

Repeated episodes of hypoglycemia are associated with reduced counterregulatory responses, including reduced (rather than enhanced [Answer C]) sympathetic and growth hormone responses. While episodes of hypoglycemia could reduce overall glycemic control and be associated with lower hemoglobin A1c levels (Answer D), in general, treatment of severe hypoglycemia results in overshoot hyperglycemia in the short-term. Long-term management is often aimed at preventing hypoglycemia with a bias toward accepting hyperglycemia. Thus, hemoglobin A1c levels are not greatly affected in many patients with severe hypoglycemia.

Educational Objective:
Describe the effect of repeated episodes of severe hypoglycemia on mortality.

Reference(s):


Question 3

Correct Answer: C. Intake of alcohol with the evening meal

Answer Rationale:
The differential diagnosis of hypoglycemia in patients with diabetes mellitus includes the intake of alcohol later in the day (Answer C), most likely related to a reduction in hepatic gluconeogenesis, as well
as a reduction in hypoglycemic awareness and a decreased counterregulatory hormone response to a decline in blood glucose levels.

Sulfonylureas (Answer A) work by stimulating endogenous insulin and can cause hypoglycemia in patients with type 2 diabetes mellitus, but not in individuals lacking endogenous insulin production. Insulin is partly cleared by renal filtration (although most is cleared by hepatic metabolism and protein degradation), so a reduction in renal function is associated with prolonged insulin half-life and higher circulating levels, with associated hypoglycemia. Recovery from an acute kidney injury (Answer B) would not be expected to cause overnight hypoglycemia. However, in chronic kidney disease, loss of renal glycogen stores can result in overnight and fasting hypoglycemia. Glucocorticoids acutely increase glycemic levels, so prednisone (Answer E) should not cause hypoglycemia. Compared with insulin glargine, insulin detemir is associated with less hypoglycemia. A switch from insulin glargine to insulin degludec (Answer D) would not be expected to cause hypoglycemia.

Other causes of hypoglycemia include insulin excess or incorrect timing of insulin dosing, a decrease in carbohydrate intake such as a missed meal, exercise, or the addition of other medications that inhibit gluconeogenesis.

**Educational Objective:**
Generate a differential diagnosis for the recent occurrence of hypoglycemia in patients with type 1 diabetes mellitus.

**Reference(s):**


**Question 4**

**Correct Answer:** D. Gastric emptying study

**Answer Rationale:**
In insulin-treated patients with diabetes, gastroparesis (delayed gastric emptying) may lead to unexplained hypoglycemia, particularly early in the postprandial period. Gastroparesis often occurs in patients with longstanding diabetes and concomitant microvascular complications. Classic autonomic neuropathy with gastroparesis is almost always accompanied by parasympathetic dysfunction resulting in resting tachycardia, which is often bothersome but not dangerous. Most patients with gastroparesis present with upper gastrointestinal symptoms, although the correlation of symptoms with delayed gastric emptying is weak, and some patients are asymptomatic. The rate of gastric emptying regulates the delivery of carbohydrates to the small intestine, and it has a major impact on postprandial blood glucose. Variations in the rate of gastric emptying account for 35% of the variance in the initial rise of blood glucose after a 75-g glucose load in healthy persons and those with diabetes. Nuclear medicine
Patients with Type 1 Diabetes – Update

scintigraphy, or gastric emptying study (Answer D), remains the criterion standard for assessing gastric emptying, although inconsistency in its use may affect its diagnostic accuracy.

Although adrenal insufficiency can be a cause of unexplained hypoglycemia in a patient with type 1 diabetes, it is a less likely diagnosis in a patient with normal blood pressure and electrolytes and without symptoms of orthostasis. Thus, an ACTH-stimulation test (Answer B) is incorrect. Similarly, while hypopituitarism is a potential cause of hypoglycemia, there is little else to support that diagnosis, and imaging of the pituitary gland (Answer E) is unlikely to yield any useful information. This patient is frustrated and stressed about her situation, and although a psychiatric evaluation (Answer A) and counseling can be helpful in dealing with any chronic condition, it is unlikely to uncover the cause of her hypoglycemia. Similarly, because she has had ongoing and recent nutrition counseling, poor carbohydrate counting skills (Answer C) are unlikely to be the reason for her frequent unexplained hypoglycemia.

*Educational Objective:*
Diagnose the etiology of unexplained recurrent hypoglycemia and glycemic variability in a patient with diabetes mellitus.

*Reference(s):*


*Question 5*

*Correct Answer: A. Increase his glucose target to 140 mg/dL (7.8 mmol/L)*

*Answer Rationale:*
Up to 30% of patients with type 1 or longstanding type 2 diabetes mellitus have impaired or absent awareness of hypoglycemia. As plasma glucose levels fall, compromised physiologic counterregulatory defenses include failure of an increase in glucagon secretion and attenuated epinephrine secretion. This, together with the inability to reduce circulating insulin levels, results in the clinical syndrome of defective counterregulation, which markedly increases the risk of recurrent severe hypoglycemia. Hypoglycemia-attenuating defense against subsequent hypoglycemia is a concept referred to as hypoglycemia-associated autonomic failure. The mainstay therapy for hypoglycemia-associated autonomic failure is the scrupulous avoidance of hypoglycemia. Patients with hypoglycemia unawareness and/or severe hypoglycemia and tight control should be advised to relax their glucose targets for a period to allow awareness to potentially return with adrenergic symptoms (Answer A).
While a patient should be advised to carry with them a source of readily absorbed glucose, if he only has neuroglycopenic symptoms, there would be nothing triggering the patient to use them, so it would be unlikely to prevent his hypoglycemia. Also, carrying a glucagon emergency kit (Answer B) would not help either as this is used by another person, not the patient, and a companion must be aware of the presence of the kit, as well as how to use it. All patients receiving insulin should carry some form of identification that describes their risk of hypoglycemia. Although an insulin pump (Answer C) may help reduce hypoglycemia, it would not address the underlying cause of the hypoglycemia unawareness (repetitive hypoglycemic episodes) or guarantee its avoidance. There would also be a delay in initiating pump therapy and a learning curve associated with its use. Even a pump with an automatic suspend function is only as good as its integrated continuous glucose sensor, which can be inaccurate. A patient using this type of pump must be reminded that he still must actively treat the hypoglycemia to prevent it from worsening. Moving the timing of basal insulin administration to the morning (Answer D) could have a modest effect on nocturnal hypoglycemia, but the kinetics of insulin glargine include a 24-hour duration of action regardless of administration timing. Thus, this strategy would not significantly alter the number of hypoglycemic events or the patient’s hypoglycemic awareness. Preemptive carbohydrate intake during the day (Answer E) may prevent some of the hypoglycemia, but it would not restore hypoglycemic awareness. This strategy is also associated with weight gain and would have no effect on overnight hypoglycemia.

Educational Objective:
Recommend appropriate management of severe hypoglycemia and hypoglycemia unawareness in a patient with type 1 diabetes mellitus.

Reference(s):


Question 6

Correct Answer: C. Initiate the use of a continuous glucose monitor

Answer Rationale:
Hypoglycemic unawareness is a common problem in patients with tightly controlled type 1 diabetes mellitus and is a major risk factor for severe hypoglycemia requiring assistance. Recurrent hypoglycemia reduces the normal counterregulatory hormone response of glucagon and epinephrine secretion to low glucose levels and decreases hypoglycemia awareness. Antecedent hypoglycemia was identified in the Diabetes Control and Complications Trial as the most common predictor of a future severe hypoglycemic event.

While this patient’s hemoglobin A1c level has run consistently in a good range, favorable mean glucose levels are occurring at the expense of recurrent hypoglycemia. Prevention of future severe hypoglycemia, a potentially life-threatening complication of insulin therapy, should be the primary concern at the time of this visit. Strict avoidance of hypoglycemia for periods as short as 3 days improves hypoglycemia awareness for up to 3 months and reduces the risk of future hypoglycemia, and it is therefore one treatment option at this juncture.

Continuous glucose monitors (Answer C) should be considered for patients with persistent hypoglycemia unawareness, given this tool’s potential to alert patients to unrecognized hypoglycemia. Continuous glucose monitors have been shown to lower hemoglobin A1c levels in adults and children with type 1 diabetes mellitus and to reduce the frequency of severe hypoglycemia among adult patients with hypoglycemia unawareness. Two hybrid systems that pair a continuous glucose monitor with an insulin pump device are now available. The glucose monitor communicates with and automatically suspends the basal insulin infusion when the glucose level is low and unrecognized. Use of these devices reduces the amount of time spent in hypoglycemia overnight. Initiating a continuous glucose monitor would be expected to reduce this patient’s risk of a severe hypoglycemic reaction in the future. Of note, not all continuous glucose monitors have alarm functions for hypoglycemia and some devices may be preferable to others when used in patients with severe hypoglycemia and hypoglycemic unawareness.

Excessive insulin dosing to correct high glucose levels can lead to hypoglycemia. A change in this patient’s insulin sensitivity factor from 40 (1 unit of glulisine to lower glucose 40 mg/dL [2.2 mmol/L]) to 20 (1 unit of glulisine to lower glucose 20 mg/dL [1.1 mmol/L]) (Answer A) would double the amount of insulin given to correct high glucose levels and would increase the risk of hypoglycemia.

In the setting of fixed premeal insulin glulisine doses, this patient’s low glucose variability suggests that he is successfully maintaining similar carbohydrate content in his meals from day to day. A change to carbohydrate counting (Answer B) would not be expected to reduce his risk of hypoglycemia. If he were commonly eating meals with different amounts of carbohydrates, adjustment of his insulin glulisine bolus based on the calculated carbohydrate content of the meal would reduce glucose variability and rates of postprandial hypoglycemia.

In adults, studies comparing continuous subcutaneous insulin infusion (insulin pumps) with basal insulin analogue glargine and lispro-based multiple daily injection regimens show small reductions in hemoglobin A1c with insulin pumps (Answer D), but not in total or severe hypoglycemia. In these studies, fasting glucose levels are similar in the 2 groups as a result of insulin titration protocols that target a fasting glucose goal.
Insulin degludec is a basal insulin with a considerably longer duration of action and lower pharmacodynamic variability than either insulin glargine or insulin detemir. Studies comparing these basal insulins in patients with type 1 diabetes mellitus have shown similar control of hemoglobin A1c, but less nocturnal hypoglycemia with insulin degludec than with insulin glargine or insulin detemir. A change from degludec to detemir (Answer E) would not be expected to reduce rates of severe hypoglycemia.

In this vignette, the severe hypoglycemia occurred after a day of increased physical activity, which is known to enhance insulin sensitivity and lower glucose levels. Although not listed as an option here, increasing carbohydrate intake or lowering insulin doses before or during exercise also reduces the likelihood of hypoglycemia.

**Educational Objective:**
Recommend interventions to reduce the occurrence of severe hypoglycemia in patients with type 1 diabetes mellitus.

**Reference(s):**


**Exercise and T1D**

**Question 1**

**Correct Answer:** A. Both temperature and altitude

**Answer Rationale:**
Several physical factors influence the accuracy of blood glucose strips; the most common are altitude and temperature (thus, Answer A is correct and Answers B, C, and D are incorrect). Glucose oxidase meters tested at 13,500 ft (4100 m) were found to overestimate the glucose concentration by 6% to 15%. In another study, glucose oxidase meters overestimated values at low pO2 levels and underestimated glucose values at high pO2 levels. Glucose dehydrogenase-based systems are oxygen insensitive and are therefore not affected by altitude. The effect of temperature is less predictable, and it can be either positive or negative at extreme cold temperatures. Temperature can affect readings indirectly as well, by influencing circulation to the skin (cold temperature), which may particularly affect
results of alternate site testing. No data are available on the effect of low barometric pressure (Answer E) on glucose meter readings.

**Educational objective:**
Identify environmental factors that can affect the accuracy of blood glucose meter readings.

**Reference(s):**


**Question 2**

**Correct Answer:** A. He should consider a brief period of weightlifting before jogging to reduce the chance of hypoglycemia

**Answer Rationale:**
With an adequate concentration of insulin on board, aerobic activity is most often associated with a slight increase, no change, or a mild decrease in blood glucose during or shortly after the activity. Anaerobic exercise, however, often induces a rise in blood glucose levels because of the excess release of catecholamines (14- to 18-fold rise). Aerobic exercise is associated with a more modest rise (2- to 4-fold) in catecholamines. Hypoglycemia is certainly still possible with aerobic exercise such as jogging, especially if the jogging is strenuous, and there is no magic number for the ideal pre-jog glucose value that will guarantee against it (thus, Answer C is incorrect). Recent evidence has shown that including small amounts of anaerobic activity (eg, weightlifting) during aerobic exercise may reduce the drop in blood glucose levels associated with moderate-intensity aerobic exercise (thus, Answer A is correct). Increasing his basal rate during jogging (Answer B) could cause great harm by increasing the insulin concentration. Physical activity is recommended for patients with type 1 diabetes because regular exercise is associated with a longer life and a lower frequency of complications (thus, Answer D is incorrect).

**Educational objective:**
Advise patients with type 1 diabetes mellitus about the effects of exercise on the risk of hypoglycemia.

**Reference(s):**


**Question 3**

*Correct Answer:* C. He should consider a brief period of weightlifting before biking or choose high intensity interval cycling to help reduce the chance of hypoglycemia

*Answer Rationale:* With insulin on board (IOB) from a prior bolus, or even with unadjusted basal insulin only, aerobic activity is associated with a significant drop in blood glucose levels (1). In contrast, brief anaerobic exercise may induce a rise in glycemia because of the large release of counterregulatory hormones (14- to 18-fold rise in catecholamines) (2-4). Hypoglycemia is certainly possible within one hour of aerobic exercise, particularly when insulin levels are elevated and the starting glucose is only mildly elevated (mean drop in glucose is about 70 mg/dL per hour, but highly variable) (thus, Answers A and B are incorrect) (5). Recent evidence demonstrates that including small amounts of anaerobic activity (eg, weightlifting, sprinting) before or during aerobic exercise reduces the drop in blood glucose levels that is normally associated with moderate-intensity aerobic exercise (thus, Answer C is correct) (6). Although caffeine intake may attenuate the drop in glycemia during exercise, it appears to increase nocturnal hypoglycemia risk after exercise (7). Physical activity is recommended for patients with type 1 diabetes because regular exercise is associated with a longer life and a lower frequency of complications (thus, Answer E is incorrect) (1).

*Educational objective:* Advise patients with type 1 diabetes mellitus about the effects of exercise on the risk of hypoglycemia.

*Reference(s):*


Question 4

Correct Answer: A. Perform urinary albumin testing at his next visit in 3 months

Answer Rationale:
The prevalence of microalbuminuria in patients with type 1 diabetes is approximately 33% after 20 years of disease. It is associated with multiple other risk factors including systolic blood pressure, duration of disease, and glycemic control. It can be a harbinger of more established nephropathy, especially if left untreated. Because patients with diabetic kidney disease are often asymptomatic, it is important to screen them regularly once they have had diabetes for 5 or more years. A spot urine to measure the ratio of albumin to creatinine is an acceptable screening method, and it is more convenient for patients than 24-hour urine collection. However, there are conditions that may lead to increased protein excretion and false-positive results including acute hyperglycemia, strenuous exercise, and prolonged standing. This patient’s recent decision to increase his aerobic exercise may be playing a role, and it would be important to query whether he had performed an intense workout or long-distance run before collecting his spot urine. Although his blood pressure is at the upper limit of normal for what is considered the target for patients with diabetes (less than 130/80 mm Hg), he is technically normotensive. Therefore, antihypertensive agents are not indicated now. To establish a diagnosis of microalbuminuria, results from 2 of 3 tests must be abnormal within a 6-month period. Repeating the test in 2 to 3 months is the most appropriate next step. You might consider advising him to refrain from training for several days before his next urine specimen collection to eliminate strenuous exercise as a confounding factor.

Educational objective:
Apply appropriate screening techniques for diabetic nephropathy.

Reference(s):

Question 5

Correct Answer: C. Proceed with an exercise regimen that includes both resistance exercises and aerobic physical activity
**Answer Rationale:**
Although recommendations in the past have suggested that patients with peripheral neuropathy should avoid weight-bearing exercises, recent evidence and guidelines indicate that exercises such as moderate-intensity walking do not increase the risk of foot ulceration in such patients. This patient may increase his weight-bearing activity, but should use proper footwear and inspect his feet daily, and the activity should be suspended if injury or ulceration occurs. His closely monitored nonproliferative retinopathy is not a contraindication to resistance exercise, although this type of activity should be avoided in patients with proliferative or severe nonproliferative retinopathy, as it may precipitate vitreous hemorrhage or retinal detachment. Although very vigorous exercise may increase proteinuria, there is no evidence that it causes progression of diabetic renal disease and should not be avoided for that reason. Hyperglycemia itself is not a contraindication to exercise if the patient feels well and is not ketotic. Screening for cardiovascular disease in asymptomatic patients with diabetes who are planning exercise is not generally indicated, although it is recommended in patients with autonomic neuropathy because this type of complication is highly associated with cardiovascular disease. Screening of asymptomatic patients who are thought to be at high risk for cardiovascular events in the short term might also be considered.

**Educational objective:**
Plan for safely increasing physical activity in patients with complicated diabetes.

**Reference(s):**


**Question 6**

**Correct Answer:** C. Temporarily lower her basal insulin rates by 10% to 15% for 6 to 12 hours after any extended aerobic exercise

**Answer Rationale:**
This patient is concerned about precipitating an adverse cardiovascular event with a sudden increase in exercise intensity. Her short duration of disease, history of good glycemic control, and absence of both microvascular complications of diabetes and other major risk factors for cardiovascular disease all confer a positive reduction in risk, although her sex, as opposed to women without diabetes, does not. Nevertheless, it is reasonable to consider whether any other risk reduction strategies should be implemented or whether screening for cardiovascular disease should be undertaken. It is important to consider that virtually all of the randomized controlled trials looking at interventions to lower the risk of cardiovascular disease have excluded patients with type 1 diabetes or have included them only as a minor subset. Therefore, results and recommendations should be interpreted with this in mind. Any intensification of an exercise regimen may increase the risk of hypoglycemia. Patients are most at risk for hypoglycemia 6 to 12 hours after exercise, when muscle and liver glycogen stores are being replenished. Therefore, an appropriate choice for this patient would be to lower her basal rate during the period when hypoglycemia would be most likely to occur.
Educational objective:
In the setting of type 1 diabetes mellitus, counsel patients on the recommendations for screening and preventive therapy for coronary artery disease and adjust insulin therapy with the initiation of strenuous exercise.

Reference(s):
Lumb AN, Gallen IW 2009 Diabetes management for intense exercise. Curr Opin Endocrinol Diabetes Obes 16:150-155

Psychosocial Well-Being of Patients with T1D

Question 1

Correct Answer: A. Depression

Answer Rationale:
This patient displays a multitude of symptoms suggesting that she has not yet come to terms with her diabetes diagnosis. Patients with diabetes can experience various stages of grief, similar to those experienced by a person dying. She is currently in the anger stage, as she has expressed hating her diagnosis. The next stages would be bargaining, depression, and acceptance. In addition to being angry about her diabetes diagnosis, she is most likely depressed (Answer A). It is possible that she may have a restrictive-type eating disorder (Answer B) and possibly a problem with narcotic abuse (Answer D). Diabulimia is an eating disorder that primarily affects women with type 1 diabetes. It is manifested by consciously omitting insulin in order to cause glycosuria and weight loss. However, of the choices provided, the one that most likely explains her symptoms and cause of diabetic ketoacidosis is depression. In patients with diabetes, depression is associated with poorer diet and nonadherence to diabetes medication. In patients with type 2 diabetes, minor depression is associated with a 1.7-fold increase in mortality, and major depression is associated with a 2.3-fold increase. Symptoms suggestive of depression in this patient are anger, multiple somatic symptoms, fatigue, loss of pleasure in normal activities (anhedonia), and sleep disturbance.

The clinician should ask open-ended questions that allow the patient to vent her frustrations and have her feelings validated. This will also build rapport. A useful starting statement might be something such as, “I can see that you are extremely frustrated about your diabetes.” It is also important not to address the factual discrepancies in her story (e.g., lack of diabetes education), as this will only cause more distress. The best next step in this patient’s case is to empathize with her and to seek the help of a behavioral expert. While endocrinologists can identify depression and eating disorders, they are not trained to treat them. Effective treatment of such patients requires a team approach. In addition to working with a psychiatrist, this patient was referred for weekly visits with a diabetes nurse practitioner who had experience working with patients with depression and eating disorders.

This patient has features of the other listed diagnoses, but none of these can explain her entire symptom complex better than depression. Although she has multiple symptoms, her history does not
suggest a factitious disorder (Answer C). She describes having pain “all over,” but this is not sufficient to diagnose fibromyalgia (Answer E).

**Educational objective:**
Identify depression as an underlying cause of treatment nonadherence in patients with diabetes mellitus.

**Reference(s):**

**Question 2**

**Correct Answer:** C. Schedule a visit with a certified diabetes educator and dietician

**Answer Rationale:**
Recently, investigators have reported on diabetes-related distress, which is experienced by many patients with diabetes and is often labeled as depression. Referral to a psychiatrist (Answer A) and eventual use of an antidepressant (Answer B) may both be necessary in the future, but the next step should be to address her stress about meal planning. Thus, scheduling a visit with a certified diabetes educator and dietician (Answer C) is correct. Although seeing her on a more frequent basis until her glycemic control improves might be warranted, without additional focus on her nutrition issues it is unlikely to be successful in isolation. This patient has not reported that the use of an insulin pump is adding to her stress, so there is no indication to discontinue it at this time (Answer E), although teaching her strategies for site rotation is warranted. Finally, her chances of having an infant with a congenital malformation are significantly increased with a hemoglobin A1c level as high as 9.1% (76 mmol/mol). She should be counseled to use some form of contraception until her hemoglobin A1c is less than 7.0% (<53 mmol/mol). Thus, referral to a fertility specialist now (Answer D) is incorrect.

**Educational objective:**
Identify signs of emotional distress in patients with poorly controlled type 1 diabetes mellitus.

**Reference(s):**

**Question 3**

**Correct Answer:** D. A consequence of negative emotions related to the daily demands of diabetes

**Answer Rationale:**
Diabetes-specific emotional distress occurs when persons with diabetes experience negative emotions (Answer D) (frustration, stress, worry, fear, exhaustion) specifically as a result of the daily demands of their condition. These emotions are often in relation to the impact of diabetes on family, work, or finances, or they can be associated with worries about complications and/or out-of-range blood glucose values.

Diabetes distress is common, as 30% to 45% of individuals with diabetes experience distress at some point in their lifetime (thus, Answer A is incorrect). Most individuals who experience significant levels of distress never become clinically depressed (thus, Answer B is incorrect). Clinical depression is associated with increased rates of diabetic ketoacidosis, but the association between distress and diabetic ketoacidosis hospital admissions is less understood (thus, Answer C is incorrect). Lack of access to appropriate medical care is indeed stressful, but it is not the cause of diabetes-specific emotional distress, which occurs regardless of access to care (thus, Answer E is incorrect).

Educational objective:
Define diabetes-specific emotional distress.

Reference(s):

Question 4
Correct Answer: D. Consult a mental health specialist to assess the role of depressive symptoms in the patient’s current behaviors and mood

Answer Rationale:
Depressive symptoms are common among teenagers with type 1 diabetes mellitus. This patient has experienced a series of challenges, including increased demands for independent self-care, an embarrassing hypoglycemic event, worsening glycemic control, increased fears and worries, decreased concentration, and loss of interest in activities she used to enjoy. Telling her parents that they must increase supervision (Answer A) before understanding more about the family dynamics may lead to increased family conflict instead of increased parental support. Frightening the patient (Answer B) with threats about the future will not increase her dedication to self-care behaviors and may negatively impact her relationship with you. Helping the school protect student privacy (Answer C) is a nice gesture, but it is not the first thing to address for this patient. Similarly, helping her garner the support of her peers (Answer E) may also contribute to longer-term success; however, it is not the first problem to address during this clinic visit.

Educational objective:
Assess the well-being of an adolescent with poorly controlled type 1 diabetes mellitus and determine an appropriate course of action.
Reference(s):


Insulin Pump Therapy

Question 1

Correct Answer: A. Aspart

Answer Rationale:
Flexibility to either increase or decrease insulin action is a cornerstone of hybrid closed-loop insulin delivery system technology. In so doing, only immediate-acting insulins are used for these devices. The table below provides a brief summary of commonly used insulins in this category: lispro, aspart, and glulisine. Each has an onset of action within 15 to 20 minutes, a peak in activity between 1 and 2 hours, and a duration of action between 3 and 6 hours. Thus, of the choices listed, insulin aspart (Answer A) is the most appropriate insulin to use in a hybrid-closed loop insulin delivery system. The other 4 options all are considered either intermediate-acting insulin (NPH) or long-acting insulin (degludec, glargine, and detemir), none of which is suitable for delivery by an insulin pump.

<table>
<thead>
<tr>
<th>Insulin</th>
<th>Onset of Action</th>
<th>Peak</th>
<th>Duration of Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lispro (U100)</td>
<td>~15 minutes</td>
<td>1-2 hours</td>
<td>3-6 hours</td>
</tr>
<tr>
<td>Aspart</td>
<td>~15 minutes</td>
<td>1-2 hours</td>
<td>3-6 hours</td>
</tr>
<tr>
<td>Glulisine</td>
<td>~20 minutes</td>
<td>1-2 hours</td>
<td>3-6 hours</td>
</tr>
<tr>
<td>NPH</td>
<td>2-4 hours</td>
<td>4-8 hours</td>
<td>10-18 hours</td>
</tr>
<tr>
<td>Glargine (U100)</td>
<td>1-2 hours</td>
<td>Minimal</td>
<td>Up to 24 hours</td>
</tr>
<tr>
<td>Detemir</td>
<td>1-2 hours</td>
<td>Minimal</td>
<td>Up to 24 hours</td>
</tr>
<tr>
<td>Degludec (U100 and U200)</td>
<td>1-4 hours</td>
<td>No significant peak</td>
<td>~42 hours</td>
</tr>
</tbody>
</table>

Educational objective:
Explain the kinetics of insulin analogues and identify which are suitable for use in hybrid closed-loop insulin delivery systems.
Question 2

Correct Answer: E. Patient intervention

Answer Rationale:
This patient’s tracing represents a user-based problem (Answer E). One of the greatest advantages of hybrid closed-loop insulin delivery systems is the management of overnight fasting glucose levels and the prevention of hypoglycemia. When in auto mode, the system uses proprietary parameters combined with continuous glucose monitor readings and “learned information” specific to the user to deliver incremental insulin dosing to maintain target glucose levels. However, some patients find it difficult to trust the system to perform in this manner. One can see from the tracing above that this patient is taking carbohydrate supplements for declining glucose levels, as well as administering additional bolus doses of insulin for hyperglycemia. Thus, there is a sinusoidal pattern to her continuous glucose monitor readout. Another notable sign of possible user entry of supplemental carbohydrate is time spent below range in excess of the typical 6% to 8%. However, in this case, the time spent below range is within normal expectations, and the sinusoidal pattern is more likely a sign of patient intervention.

The pump and continuous glucose monitor are working properly. Her numerous manual fingerstick measurements closely reflect the values logged by the monitor (thus, Answers B and C are incorrect). While both pituitary and adrenal insufficiency (Answers A and D) could cause hypoglycemia, they are unlikely to cause both hypoglycemia and hyperglycemia and are improbable in this patient.
**Educational objective:**
Interpret the data output from a hybrid closed-loop insulin delivery system and apply that information to problem solving for hypoglycemic and hyperglycemic excursions.

**Reference(s):**


**Question 3**

**Correct Answer:** C. Current capillary glucose value

**Answer Rationale:**
In a hybrid closed-loop insulin delivery system, mealtime insulin coverage requires that the user enter specific information to use the bolus calculator to calculate a mealtime dose. The determination of mealtime dosing takes into account the amount of carbohydrates to be consumed, the current capillary glucose level (Answer C), and the timing/magnitude of previous bolus doses of insulin. The bolus calculator determines the amount of insulin needed to process carbohydrate intake, as well as to correct (upward or downward) for the current glycemic status, and adjusts for prevailing insulin action based on prior insulin dosing within the preset active insulin time parameter. Thus, the bolus calculator automatically determines the proper bolus dosing with only the carbohydrate count (not provided as an answer choice in this vignette) and current capillary glucose level. Neither the time of any previous manual insulin bolus (Answer B) nor the active insulin time (Answer D) is used. The sensitivity factor (Answer E) used to correct for glycemic status and carbohydrate ratio are preprogrammed into the pump and do not require entry at each meal. Of note, the carbohydrate ratio and sensitivity factor may vary with each meal. The recent trend in glycemic level, either up or down (Answer A), is not factored into the calculated dose by the bolus calculator.

**Educational objective:**
List the parameters used in calculating mealtime coverage with the bolus calculator of a hybrid closed-loop insulin delivery system.

**Reference(s):**
Question 4

Correct Answer: B. Basal Rate = 0.6 units/h; Carbohydrate Ratio = 1 units/15 g; Sensitivity Factor = 1 unit/55 mg/dL

Answer Rationale:
Understanding how to convert a regimen of multiple daily injections to continuous subcutaneous insulin infusion is very important. Many articles explain the conversion, all summarized nicely in the 2014 American Association of Clinical Endocrinologists/American College of Endocrinology Consensus Statement, although practical application for some patients may vary slightly regarding the conversion numbers. As an example, the anticipated pump total daily dose (pump TDD) is often calculated as 75% of the pre-pump TDD, depending on the patient’s glycemic control. Basal rate is half the pump TDD divided by 24 to account for hourly basal insulin and not bolus insulin. The carbohydrate ratio is approximately 450 to 500 divided by the pump TDD, and the sensitivity factor is 1700 to 1800 divided by the pump TDD. As equations:

Starting estimations:
Pre-pump TDD = 40 units
Anticipated pump TDD = (pre-pump TDD) x 0.75 = 40 units x 0.75 = 30 units

Parameters:
Basal rate = (pump TDD x 0.5) / 24 h
Carbohydrate ratio = 450 / pump TDD
Insulin sensitivity factor = 1700 / pump TDD

Thus, the optimal parameters among the options are listed in Answer B.

Educational objective:
Convert a regimen of multiple daily insulin injections to insulin pump therapy in a patient with type 1 diabetes mellitus.

Reference(s):

Question 5

Correct Answer: D. Hybrid closed-loop insulin pump and continuous glucose monitoring system

Answer Rationale:
This patient with type 1 diabetes is not meeting reasonable glycemic targets despite adherence to recommendations for self-monitoring and lifestyle. His main issue is the variability of his lifestyle and physical activity. Exploration of technologic solutions is indicated.

Real-time continuous glucose monitors (CGMs) (Answer B) have been studied extensively. Most studies are of relatively short duration, between 12 weeks and 6 months, but they generally show modest reductions in hemoglobin A1c and less time spent in hypoglycemia, although not all studies demonstrate both effects. It is notable that hypoglycemia unawareness is not a reported problem for this patient. While the use of a CGM would certainly provide him with some benefit, there may be better options. Current glucose monitoring systems allow the patient to obtain glucose values by waving the reader close to the sensor, which is inserted into the upper arm. Although it is an attractive option to replace frequent fingerstick blood glucose measurements, the flash glucose monitoring system (Answer E) does not have the option to alert patients if hypoglycemia occurs. While this patient retains hypoglycemia awareness, the flash glucose monitoring system would not be the best choice because he reports frequent hypoglycemia.

Recently, the US FDA approved an insulin pump and CGM to operate in so-called hybrid closed-loop mode (Answer D). This insulin pump has an “auto mode” whereby the pump receives glucose data from the CGM and continuously adjusts the basal rates based on an algorithm. Also, it calculates the insulin sensitivity (or correction) factor based on machine learning algorithms. The patient must enter the number of carbohydrates being consumed, and the physician must set the insulin-to-carbohydrate ratio. This latter point is important—the hybrid closed-loop requires patient adherence to dietary recommendations and patient input at meal times. The pump can operate in a “manual mode” where the algorithm is inactive. Studies comparing the hybrid closed-loop system used in auto mode vs manual mode have shown increased time in the target glycemic range, lowered hemoglobin A1c, and decreased hyperglycemia and hypoglycemia. Although the largest of such studies was a single-arm, nonrandomized study, the balance of evidence suggests that in this patient with an erratic lifestyle and frequent hypoglycemia, hybrid closed-loop technology would be the best option to optimize glucose control.

Continuous subcutaneous insulin injection (CSII) or insulin pump therapy alone (Answer A) may improve glycemic control, although the bulk of this evidence is from studies comparing CSII with the use of intermediate-acting recombinant insulin. Studies comparing CSII alone with a regimen of multiple daily injections with a modern insulin analogue suggest that CSII results in reduced glycemic variability and lower hemoglobin A1c values in patients who have higher hemoglobin A1c values to start. CSII with integrated CGM with the threshold suspend feature (Answer C) most likely improves rates of hypoglycemia and may represent a better option than CSII alone. However, the patient retains hypoglycemia awareness and this approach would not address his variable lifestyle. As studies with hybrid closed-loop insulin delivery systems have been compared with the same pump operating in auto mode vs manual mode, the hybrid closed-loop system is most likely the best choice for this patient.
**CSII/CGM type**  | **Adjusts Basal Rate Continuously** | **Temporarily Stops Insulin Delivery at a Given Glucose Threshold** | **Requires Patient to Announce Meal and Enter Carbs** | **Requires Insulin Sensitivity Factor to Be Determined By Provider**
--- | --- | --- | --- | ---
CSII + CGM | No | No | Yes | Yes
CSII + CGM + Threshold Suspend | No | Yes | Yes | Yes
CSII + CGM + Hybrid Closed-Loop | Yes | Yes | Yes | No

*Educational objective:*  
Optimize glycemic control in a patient with type 1 diabetes mellitus and hypoglycemia who has a variable schedule.

*Reference(s):*  


**DKA Management**

**Question 1**

*Correct Answer:* C. Contact her pharmacy to determine when the prescriptions for insulin and syringes were last filled

*Answer Rationale:*  
Diabetic ketoacidosis (DKA) is a common, life-threatening complication of diabetes, accounting for as many as 4% to 9% of all hospital admissions for patients with diabetes. There are many precipitating causes for DKA development, the most common being undertreatment or omission of insulin, the presence of comorbid conditions, illicit drug use, and previously undiagnosed diabetes. This patient reports adherence to her insulin regimen, but she is upset about her weight gain over the past 2 years, so the possibility of nonadherence should be seriously considered. One way of assessing a patient’s adherence is to contact her pharmacy to determine when prescriptions were refilled (Answer C).

Although this patient’s serum creatinine is elevated, there is clear evidence of volume depletion, and this is a more likely reason for her azotemia than acute kidney injury (Answer A). Atypical antipsychotic agents have been linked to weight gain and rarely DKA, but these instances have been in the setting of type 2 diabetes (thus, Answer B is incorrect). Although the patient’s total daily insulin dose is relatively low (0.5 units/kg per day), it should be adequate to prevent the development of DKA, if not to maintain...
perfect control, if she were taking all her doses (thus, Answer D is incorrect). In fact, if you increase her
dose and she begins taking it as prescribed, it could cause dangerous hypoglycemia.

**Educational objective:**
Differentiate among common precipitating causes of diabetic ketoacidosis.

**Reference(s):**
Kitabchi AE, Umpierrez GE, Fisher JN, Murphy MB, Stentz FB. Thirty years of personal experience in
hyperglycemic crises: diabetic ketoacidosis and hyperglycemic hyperosmolar state. *J Clin Endocrinol

Kitabchi AE, Umpierrez GE, Miles JM, Fisher JN. Hyperglycemic crises in adult patients with diabetes.

Steenkamp DW, Alexanian SM, McDonnell ME. Adult hyperglycemic crisis: a review and perspective.

Guenette MD, Hahn M, Cohn TA, Teo C, Remington GJ. Atypical antipsychotics and diabetic ketoacidosis:

**Question 2**

**Correct Answer: C**

**Answer Rationale:**
Diabetic ketoacidosis is a life-threatening complication of severe insulin deficiency that is commonly
seen in patients with newly diagnosed type 1 diabetes. However, it can also occur in patients with type 1
diabetes who interrupt basal and bolus insulin for more than 24 hours, or in those on insulin pump
therapy whose rapid-acting insulin analogue infusion is interrupted for more than 4 to 6 hours. Diabetic
ketoacidosis may also complicate severe stressful illness in patients with type 1 or type 2 diabetes.

The severity of ketoacidosis is determined on the basis of the arterial pH, serum bicarbonate, and
alteration in sensorium:

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arterial pH</td>
<td>7.25-7.30</td>
<td>7.00-7.24</td>
<td>&lt;7.00</td>
</tr>
<tr>
<td>Serum bicarbonate</td>
<td>15-18 mEq/L (15-18 mmol/L)</td>
<td>10-14 mEq/L (10-14 mmol/L)</td>
<td>&lt;10 mEq/L (&lt;10 mmol/L)</td>
</tr>
<tr>
<td>Alteration in sensorium</td>
<td>Alert</td>
<td>Alert/drowsy</td>
<td>Stupor/coma</td>
</tr>
</tbody>
</table>

The standard of treatment of severe diabetic ketoacidosis involves aggressive fluid resuscitation;
intravenous insulin; repletion of potassium; and close monitoring of hydration status, glucose, acidosis,
and electrolytes. Following serum carbon dioxide or venous pH has mostly replaced following the
arterial pH (Answer A) to assess adequacy of therapy. This avoids the pain and potential complications of serial arterial blood gas determinations. Venous pH is about 0.03 units lower than arterial pH, a nonclinically significant difference. Insulin therapy is the primary intervention to correct acidosis and it acts by inducing the metabolism of the ketoacids b-hydroxybutyrate and acetoacetate to bicarbonate. Insulin directly inhibits lipolysis and ketogenesis, promotes clearance of free fatty acids, and inhibits fatty acid oxidation to ketones in the liver. Administration of bicarbonate (Answer B) to patients with diabetic ketoacidosis who present with a pH as low as 6.9 has not been shown to speed correction of acidosis or reduce mortality. No randomized controlled studies of bicarbonate use have been performed in patients with a pH below 6.9. In those with marked hyperkalemia complicating ketoacidosis, bicarbonate can be used to accelerate the intracellular translocation of potassium from the intravascular space.

When treating ketoacidosis, intravenous insulin must be continued until the acidosis has cleared. To prevent hypoglycemia from occurring with continued intravenous insulin infusion, it is recommended that 5% dextrose be added to intravenous fluids when glucose levels fall below 200 mg/dL (<11.10 mmol/L) (thus, Answer C is correct). Normalization of acidosis, ketosis, and hyperglycemia is similar when intravenous regular insulin is compared with intravenous rapid-acting insulin (thus, Answer D is incorrect). In studies of patients with mild to moderate acidosis, equivalent rates of correction of acidosis, clearance of ketones, and glucose decline have been documented with intravenous regular insulin vs subcutaneous rapid-acting insulin administered every 1 to 2 hours. However, comparison of these 2 insulin regimens has not been well studied in patients with severe acidosis, in whom the rate of insulin administration can be more rapidly titrated with an intravenous insulin drip (thus, Answer E is incorrect).

Alterations in serum sodium are common in patients presenting with ketoacidosis. Hyperglycemia leads to the movement of intracellular water osmotically to the intravascular space, causing hyponatremia. Glucosuria leads to an osmotic diuresis of water in excess of sodium, increasing serum sodium. Hypernatremia is typically seen only with more severe hyperglycemia and dehydration. Marked hyperlipidemia can be seen in ketoacidosis, causing pseudohyponatremia as elevated lipids reduce the measured serum sodium concentration. Abnormalities of serum sodium in ketoacidosis correct after treatment with insulin and fluid resuscitation.

Educational Objective:
Treat advanced diabetic ketoacidosis.

Reference(s):


Question 3

Correct Answer: D

Answer Rationale:
Although many of the options listed would be appropriate actions for this patient to take, it is critical that he immediately deliver a dose of fast-acting or rapid-acting insulin via standard injection to prevent worsening ketosis and/or ketoacidosis (Answer D). Once this is performed, he should increase his intake of oral fluids and monitor his blood glucose every 1 to 2 hours until his target blood glucose values are reached. If no reason for his hyperglycemia is readily identified, a change in his entire infusion apparatus and insulin is indicated (Answer B), but this should not precede delivery of insulin via standard injection. Delivery of a correction bolus via the pump (Answer C) may not be an effective first step if there are issues interfering with insulin delivery via the device or infusion set, or if the insulin in his pump reservoir has deteriorated. If his hyperglycemia and ketosis do not resolve or if he is unable to tolerate oral hydration, he should be instructed to present to the emergency department for further care (Answer E). Increasing physical activity (Answer A) will not address his insulin insufficiency, and is not the appropriate next step to address his hyperglycemia and ketonuria.

Educational Objective:
Select the appropriate response to acute and unexplained hyperglycemia and ketosis in patients using an insulin pump to manage type 1 diabetes mellitus.

Reference(s):


Hospital Management of Patients with T1DM

Question 1

Correct Answer: C

Answer Rationale:
Patients with type 1 diabetes mellitus on intravenous infusions who are transferring from the intensive care unit to a medical-surgical ward require transition to subcutaneous insulin management, with appropriate replacement of basal, nutritional, and corrective (supplemental) insulin. Subcutaneous insulin amounts can be calculated from the estimated total daily insulin dose while on stable intravenous insulin therapy. Anywhere from 40% to 80% of the estimated total daily insulin dose can be administered as basal insulin replacement, preferably with a long-acting insulin analogue. Nutritional coverage of meals, enteral feeds, or parenteral infusions, preferably using a rapid-acting analogue, with a corrective insulin algorithm, can be administered to maintain preprandial blood glucose levels below 140 mg/dL (<7.8 mmol/L) and random blood glucose less than 180 mg/dL (<10.0 mmol/L) (thus, Answer
C is correct). Answer A is incorrect because there is no prandial insulin coverage included, only correction insulin. Answer B is incorrect because the target blood glucose level is lower than that recommended by the American Diabetes Association or the American Association of Clinical Endocrinologists. Answer D is incorrect because there are no recommendations in the hospital setting to adjust insulin on the basis of postprandial levels.

Educational objective:
Devise a rational plan for transitioning from intravenous insulin to a subcutaneous insulin regimen in hospitalized patients.

Reference(s):


Question 2
Correct Answer: C

Answer Rationale:
Patients on established insulin pump therapy may be appropriate candidates for pump use in the hospital provided certain conditions are met. Clear policies and procedures should be established at institutions that permit use of this technology in the inpatient setting. Candidates for inpatient self-management via insulin pump must be physically and mentally able to monitor their blood glucose levels and administer insulin safely via the device, and they should also be proficient in carbohydrate counting if this method is used in the calculation of mealtime insulin doses. The presence of the insulin pump and orders corresponding to blood glucose testing, pump usage, and insulin delivery should be clearly outlined in the medical record. Nursing personnel should document blood glucose results, basal rates, and bolus insulin amounts administered at least daily, and this information should be recorded in a format that is accessible to all caregivers. In addition, hospital personnel with expertise in the management of insulin pump therapy must be available at all times.

This hospitalized patient successfully manages her type 1 diabetes with an insulin pump in the outpatient setting. She is recovering from her postoperative complications, has begun to eat solid food, and will most likely be discharged from the hospital in the near future. Thus, it is quite reasonable to plan a corresponding change in her insulin regimen. However, the choice of transition from intravenous insulin infusion to a subcutaneous insulin regimen consisting of scheduled basal and rapid-acting analogue insulins (Answer C) is the only appropriate listed option. The suggested dose of basal insulin
Patients with Type 1 Diabetes – Update

listed is close to the amount of basal insulin used in the outpatient setting, and it is approximately 80% of her recent basal insulin requirements in the hospital. Patients who have begun eating should receive prandial insulin coverage, thus continuation of management via the intravenous insulin infusion alone until eating more at meals (Answer A) is not correct and might unnecessarily prolong her hospital stay. Use of a subcutaneous regimen that provides supplemental rather than scheduled insulin with meals (Answer B) is also incorrect as it will not adequately address the patient’s prandial coverage requirements. As outlined in Answer C, patients who are eating somewhat inconsistently may have their prandial insulin given immediately after meals at doses appropriate for their food intake and proportional to their basal insulin requirements.

Although this patient’s home insulin use via the pump appears to correspond to her current insulin requirements, she continues to receive narcotics for pain management and is somnolent and disoriented on physical examination. Patients with an altered state of consciousness are not candidates for diabetes self-management, thus neither resumption of insulin pump therapy at her usual settings (Answer D) nor pump use at reduced basal and bolus delivery settings (Answer E) would be appropriate now. If a patient is not able to independently manage an insulin pump, some institutions will permit a family member or significant other to assist with pump management. However, this individual must be trained in pump use and must stay with the patient at all times during the hospitalization to operate the device.

Educational objective:
Identify acceptable conditions for insulin pump use in the hospital.

Reference(s):

Question 3

Correct Answer: B

Answer Rationale:
Continuous subcutaneous insulin infusion from an insulin pump depends on reliable delivery of the pumped insulin to the subcutaneous insulin depot by means of an insulin infusion set.

Hyperglycemia with ketosis/ketonuria is evidence of insulin deficiency. Because the insulin pump only uses rapid- or short-acting insulin, even a partial interruption of insulin delivery can rapidly result in hyperglycemia and complete interruption of insulin delivery can result in ketosis or ketoacidosis within a few hours. Interruption of insulin infusion owing to an infusion set failure is a common cause of
otherwise unexplained (i.e., in the absence of illness or other obvious cause) metabolic deterioration in patients with type 1 diabetes mellitus who use an insulin pump.

The cannula of an infusion set can easily dislodge resulting in failure to deliver insulin into the subcutaneous tissue. This can easily occur during sleep (or at other times) without the patient recognizing that it has occurred.

The first step in managing this emergency is to assume that there has been a failure of insulin delivery and immediately inject a correction dose of rapid-acting insulin using a pen or syringe, thereby ensuring the patient has received the insulin. Thereafter, the infusion set should be replaced and the patient should continue to monitor blood glucose and ketone levels every 1-3 hours until the acute metabolic deterioration resolves.

Educational objective:
Recognize common causes of unexpected hyperglycemia in a patient with type 1 diabetes.

Reference(s):


Question 4
Correct Answer: E

Answer Rationale:
The interest in the use of continuous glucose monitoring in both hospitalized and ambulatory patients has grown considerably. There was particular interest in using these devices in critically ill hospitalized patients after one study showed reduced mortality in some patients treated with intensive insulin therapy. However, the risk for hypoglycemia in this patient population was increased. Moreover, the favorable results with the use of intensive insulin therapy have not been replicated in other studies. Importantly, the accuracy of continuous glucose monitoring is diminished in the setting of hypoglycemia, and continuous glucose monitoring has not been adequately tested in conditions common to the operating room or intensive care units, such as high oxygen tension, use of pressors, hypotension, or acidosis (thus, Answers A, B, and C are incorrect). Continuous glucose monitoring may be superior to point-of-care testing in detecting unrecognized hypoglycemia between point-of-care measurements. In ambulatory adult patients, the use of continuous glucose monitoring has been shown to be beneficial in patients with hemoglobin A1c levels either greater than 7.0% (>53 mmol/mol) (uncontrolled) or 7.0% or lower (≤53 mmol/mol) (controlled), as long as they have demonstrated that they are capable of using the device on a nearly daily basis (thus, Answer E is correct). Continuous glucose monitoring is also a useful tool in providing short-term retrospective analysis of glycemic control.
in ambulatory patients with diabetes, particularly in detecting nocturnal hypoglycemia, the dawn phenomenon, and postprandial hyperglycemia and in assisting in the management of hypoglycemic unawareness. However, continuous glucose monitoring is not an approved method of diagnosing diabetes (thus, Answer D is incorrect).

*Educational Objective:*
Recommend appropriate use of continuous glucose monitoring in patients with type 1 diabetes mellitus.

*Reference(s):*