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ORIGINAL ARTICLE

Improving the Management of Diabetes in Hospitalized Patients: The Results of a Computer-Based House Staff Training Program

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Abstract

Background: Poorly controlled diabetes in hospitalized patients is associated with poor clinical outcomes. We hypothesized that computer-based diabetes training could improve house staff knowledge and comfort for the management of diabetes in a large tertiary-care hospital.

Methods: We implemented a computer-based training program on inpatient diabetes for internal medicine house staff at the Brigham and Women's Hospital (Boston, MA) in September 2009. House staff were required to complete the program and answer a set of questions, before and after the program, to evaluate their level of comfort and knowledge of inpatient diabetes. Chart reviews of all non–critically ill patients with diabetes managed by house staff in August 2009 (before the program) and December 2009 (after the program) were performed. Chart reviews were also performed for August 2008 and December 2008 to compare house staff management practices when the computer-based educational program was not available.

Results: A significant increase in comfort levels and knowledge in the management of inpatient diabetes was seen among house staff at all levels of training ($P < 0.02$), but the increase was smaller for senior house staff compared with junior house staff. Nonsignificant trends suggesting increased use of basal-bolus insulin ($P = 0.06$) and decreased use of sliding-scale insulin ($P = 0.10$) were seen following the educational intervention in 2009, whereas no such change was seen in 2008 ($P > 0.90$). Overall, house staff evaluated the training program as "very relevant" and the technology interface as "good."

Conclusions: A computer-based diabetes training program can improve the comfort and knowledge of house staff and potentially improve their insulin administration practices at large academic centers.

Introduction

Poorly controlled diabetes in hospitalized patients is associated with poor clinical outcomes.[1,2] Therefore, comprehensive guidelines to improve management of inpatient diabetes have been developed by the American Diabetes Association (ADA) and the American Association of Clinical Endocrinologists (AACE).[3,4] For example, basal-bolus insulin regimens have been shown to improve glycemic control and decrease the risk of hospitalization-related complications when compared with sliding-scale insulin regimens[5,6] and are therefore recommended for hospitalized patients.[3] However, these recommendations are not uniformly followed for all hospitalized patients. In one study, 25–58% of hospitalized patients with diabetes were receiving sliding-scale insulin alone.[7]

Many hospitals have tried to address the problem of hyperglycemia by setting up diabetes quality improvement programs, but these efforts have generally been insufficient, yielding only marginal improvements in overall glycemic control.[8–10] These efforts have included establishing inpatient diabetes management teams, increased involvement of nurses and pharmacists in diabetes care, and implementation of standardized order sets.[7,11–13] Medical house staff also play a significant role in the management of diabetes in hospitalized patients at most U.S. hospitals. A study of graduating fourth-year medical students demonstrated gaps in knowledge regarding inpatient diabetes.[14] The students frequently recommended the sole use of sliding-scale insulin for management of diabetes in the hospital.[14] Therefore, improvements in house staff training may represent a key strategy to improve the management of diabetes in

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hospitalized patients, especially those in academic medical centers. We implemented a computer-based house staff training program that included all aspects of the management of inpatient diabetes and hypothesized that it would improve house staff comfort, knowledge, and management of non–critically ill hospitalized patients with diabetes.

Methods

The primary aim of this study was to evaluate the effect of the training program on house staff knowledge and comfort in the management of inpatient diabetes. This aim was achieved via questionnaires before and after the implementation of the training program in September 2009. Our secondary aim was to evaluate whether patient management practices of the entire residency program improved as a result of the training program. For this, we conducted a retrospective study collecting data from patient records before and after the training in 2009 and comparative months in 2008.

Computer-based educational intervention

During the month of September of 2009, internal medicine house staff at the Brigham and Women's Hospital (Boston, MA) underwent a department-wide computer-based educational course. Ten case-based interactive lesson modules were designed by the endocrinology faculty; each lesson was designed to take approximately 10–15 min to complete and was available remotely to all house staff with computer and Internet access. The course was administered by an online medical education company (PRESENT e-Learning Systems, Boca Raton, FL). The modules could be completed in multiple steps but could not be fast-forwarded or skipped. Computer software kept track of each trainee's progress. The program was accessible only during the assigned time period.

The lesson modules addressed the following topics: (1) initiating insulin in a patient new to insulin, (2) management of hypoglycemia, (3) management of diabetic ketoacidosis, (4) nutritional therapy in a hospitalized patient with diabetes, (5) insulin therapy in a patient with diabetes on "nothing by mouth" orders, (6) effective titration of basal-bolus insulin regimens, (7) management of diabetes in pregnancy, (8) management of insulin therapy in the intensive care unit, (9) management of patients on continuous insulin infusion pumps, and (10) discharge planning for patients with diabetes. The modules were designed by senior endocrinologists with long experience in the management of inpatient hyperglycemia and covered all areas included in the ADA and the AACE consensus statements on inpatient diabetes.[3] Each lesson consisted of didactic and interactive multiple-choice questions with detailed answers and explanations; lesson modules included text dialogue in a slide presentation format along with audio narrated explanations. House staff were required to complete all lesson modules during the month of September 2009. They were also required to complete a questionnaire before and after the computer-based educational intervention to evaluate their level of comfort (Appendix 1) and knowledge (Appendix 2) in frequently encountered scenarios in the management of inpatient diabetes. Comfort level was graded on a scale of 1–5 in nine areas of diabetes management, with 5 as the highest comfort level and 1 as the lowest comfort level. Knowledge was graded by adding the number of correct responses to 23 questions.

Patient chart reviews

To evaluate the effectiveness of the computer-based educational intervention, the management of diabetes by house staff was evaluated in August 2009 (1 month before the intervention) and in December 2009 (3 months following the intervention) using chart reviews of all non–critically ill inpatients with diabetes (ICD-9 code 250.xx) admitted to internal medicine services managed by house staff. The chart reviews were carried out by endocrinology fellows and faculty to assess management strategies related to diabetes. Because house staff exposure and experiences change over time, we recognized that there may be a time-dependent improvement in house staff comfort and ability to manage diabetes in hospitalized patients. Therefore, we also retrospectively evaluated the management of inpatient diabetes by house staff during the antecedent year (August 2008 and December 2008) using chart reviews of all non–critically ill inpatients with diabetes admitted to house staff–run internal medicine services. This parallel evaluation from the prior year was used to reflect house staff performance in the absence of any educational intervention. House staff in both the intervention group (2009) and the retrospective comparison group (2008) consisted of postgraduate years (PGY)-1, PGY-2, and PGY-3 house staff. The protocol for the patient chart reviews was approved by the Human Research Committee/Institutional Review Board, and a waiver to obtain informed consent was provided.

Outcome measures

The primary outcomes of interest were self-reported house staff comfort and objective knowledge in the management of inpatient diabetes based on questionnaires completed before and after the computer-based intervention. Secondary outcomes included clinical surrogates of competent inpatient diabetes management based on chart reviews before and after the computer-based intervention. The main clinical surrogates of interest included the use of basal-bolus insulin strategies (using human insulin or insulin analogs), the use of sliding-scale insulin therapy alone, and the incidence of hyperglycemia (blood glucose >250 mg/dL) and hypoglycemia (blood glucose <70 mg/dL). These clinical surrogates were selected because they are supported by professional society guidelines in the clinical care of inpatient diabetes and because these metrics could be objectively assessed with ease.

Statistical methods

All available house staff were involved in the study. All data are expressed either as number with percentages or as means with SDs. The individual item comfort level data were analyzed using a proportional odds model with house staff as a random effect. The full model included time (before vs. after computer-based training), increasing PGY level (1, 2, or 3), and the interaction. Knowledge scores were derived by assigning 1 point for each correct answer and 0 for wrong or missing answer. The summary knowledge score data were analyzed using a mixed model with the same random effect, main effects, and interaction as the comfort data. Where the interaction was significant, the effect of time was analyzed within each year, using an α level adjusted for three comparisons.

Surrogates of competent clinical practice were secondary outcomes. These data were analyzed by logistic regression

Table 1. Characteristics of Internal Medicine House Staff

	House staff class of 2009 (n = 194)			*House staff class of 2008 (n = 195)*		
	PGY-1	*PGY-2*	*PGY-3*	*PGY-1*	*PGY-2*	*PGY-3*
Number	75	61	58	74	58	62
Preliminary (%) (only 1 year of internal medicine)	21.3			21.6		
Categorical (%) (3 years of internal medicine)	56.0	67.2	51.7	52.7	67.2	53.2
Primary care (%) (internal medicine with primary care focus)	16.0	19.7	24.1	16.2	22.4	19.4
Medicine–pediatrics (%) (combined internal medicine and pediatrics training)	5.3	6.6	15.5	5.4	6.9	14.5
Global health (%) (combined domestic and global internal medicine training)	0.0	6.6	20.7	4.1	10.3	16.1

House staff had a variety of concentrations within internal medicine; some house staff had more than one concentration.
PGY, postgraduate year.

analysis for nominal variables and analysis of variance for continuous variables. The main effects were group (2009 intervention vs. 2008 comparison), month (August vs. December), and the interaction. A significant interaction would suggest that the effect of month (August vs. December) was different in 2009 when training occurred, compared with 2008 when no training occurred. Within the model, a priori contrast of August versus December in each group was also analyzed to separately assess the effect of month with and without training. SAS version 9.2 (SAS Institute, Cary, NC) was used for all analyses.

Results

Of the 194 total house staff in Fall 2009, 165 (85%) completed all aspects of the training program. Twenty-nine house staff did not participate in the training program because they were either on vacation or rotating outside the Department of Medicine during the month of September 2009 (five were PGY-1, five were PGY-2, and 19 were PGY-3). The demographic distributions of all house staff in Fall 2009 when the computer-based intervention was implemented and in Fall 2008 when no computer-based intervention took place were similar (Table 1). The PGY-3 populations were approximately 40% smaller than the PGY-1 populations, accounting for the number of house staff in both groups who were either interns completing their "preliminary year" in internal medicine before transitioning to a different specialty or residents who completed residency early ("fast-track") to enter a subspecialty of internal medicine.

Comfort and knowledge levels in managing inpatient diabetes before and after computer-based intervention

Self-reported comfort and knowledge levels in frequently encountered scenarios in managing diabetes for the house staff who completed the training program are shown in Table 2.

Table 2. Levels of Comfort and Knowledge in Inpatient Diabetes Management Before and After the Training Course

	PGY-1 (n = 70)		*PGY-2 (n = 54)*		*PGY-3 (n = 41)*	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*
Comfort level						
Treating diabetic ketoacidosis	2.76 ± 0.86	4.03 ± 0.48	3.51 ± 0.82	4.22 ± 0.69	4.05 ± 0.59	4.61 ± 0.49
Ordering the right diet for an inpatient with diabetes	3.70 ± 0.77	4.50 ± 0.61	4.31 ± 0.67	4.56 ± 0.74	4.41 ± 0.63	4.71 ± 0.46
Managing an inpatient with type 2 diabetes whose status is "nothing by mouth"	3.56 ± 0.71	4.41 ± 0.63	4.07 ± 0.87	4.52 ± 0.72	4.44 ± 0.59	4.71 ± 0.46
Managing an inpatient with type 1 diabetes	3.26 ± 0.90	4.09 ± 0.65	3.81 ± 0.88	4.19 ± 0.83	3.88 ± 0.75	4.34 ± 0.53
Discharging a patient with newly diagnosed hyperglycemia	2.97 ± 0.78	3.99 ± 0.67	3.69 ± 0.97	4.20 ± 0.86	3.85 ± 0.79	4.46 ± 0.60
Starting a patient on an insulin drip	2.50 ± 1.10	4.19 ± 0.75	3.54 ± 0.88	4.48 ± 0.84	4.32 ± 0.69	4.71 ± 0.46
Converting an inpatient from an insulin drip to subcutaneous insulin	2.40 ± 1.03	4.41 ± 0.55	3.42 ± 0.81	4.50 ± 0.75	3.73 ± 0.74	4.68 ± 0.47
Starting insulin in a patient who previously had not required insulin	3.21 ± 1.01	4.30 ± 0.60	3.76 ± 0.95	4.57 ± 0.74	3.88 ± 0.81	4.61 ± 0.49
Diagnosing and treating hypoglycemia	3.40 ± 0.91	4.46 ± 0.72	4.09 ± 0.73	4.70 ± 0.66	4.27 ± 0.59	4.73 ± 0.45
Knowledge level						
Number of correct answers	15.6 ± 2.7	19.8 ± 1.8	17.4 ± 2.1	20.6 ± 1.3	17.2 ± 1.9	19.8 ± 1.8

The provided answers ranged on a scale of 1–5 as follows: 5 = completely comfortable; 4 = somewhat comfortable; 3 = so-so; 2 = somewhat comfortable; 1 = completely uncomfortable.
P for all pairwise comparisons between pre- and post-training < 0.001.
PGY, postgraduate year.

Table 3. Clinical Outcomes Before and After the Computer-Based Intervention (2009) and in the Retrospective Comparison Year (2008)

	Intervention group		*Comparison group*	
	August 2009	*December 2009*	*August 2008*	*December 2008*
Charts reviewed (all patients with diabetes hospitalized to medicine wards staffed by house staff)	108	113	92	92
HbA1c obtained in the hospital when no prior value was available within 3 months (% of patients)	55	58	57	64
Sliding-scale insulin used alone for >48 h (% of patients)	25	15	35	34
Basal bolus insulin prescribed during hospitalization (% of patients)	35	48	42	43
Average number of titrations in basal insulin in response to hyper- or hypoglycemia per patient	0.31 ± 0.84	0.34 ± 0.87	0.30 ± 0.72	0.47 ± 1.09
Average number of days per patient with one blood glucose >250 mg/dL	1.00 ± 1.43	1.06 ± 1.67	0.87 ± 1.37	1.09 ± 1.59
Average number of days per patient with one blood glucose <70 mg/dL	0.32 ± 0.72	0.31 ± 0.72	0.18 ± 0.57	0.29 ± 0.66
Use of oral hypoglycemic agents in the hospital (% of patients)	10.2	5.3	4.3	7.6
Average length of hospital admission (days)	3.81	4.04	3.79	4.16

P = not significant for all comparisons.
HbA1c, glycosylated hemoglobin.

As expected, PGY-2 and PGY-3 house staff responded with higher comfort levels and had a higher knowledge score pre-training compared with PGY-1 house staff (Table 2); however, a uniform improvement in comfort and knowledge levels was seen in all house staff following completion of the computer training program. For each comfort question, the effect of training was significant overall and in each year ($P < 0.02$). A significant interaction for all variables except for "starting insulin on a patient that previously had not required insulin" showed that the effect of training diminished for higher PGY level (the absolute improvement in subjective comfort and knowledge was smaller for higher PGY levels compared with lower PGY levels), while still significantly increasing comfort and knowledge throughout.

Assessment of clinical management outcomes before and after computer-based training

On logistic regression analysis, no statistically significant differences in clinical practice measures were associated with the training program in the intervention group or with time in the comparison group (Table 3). However, trends toward increased use of basal-bolus insulin regimens ($P = 0.06$) and decreased use of sliding-scale insulin alone ($P = 0.10$) were observed following the educational intervention in 2009 that were not seen in the 2008 comparison group ($P = 0.90$ and $P = 0.98$, respectively) (Table 3). In contrast, neither the computer-based training in 2009 nor time in 2008 changed the incidence of hyper- or hypoglycemic episodes or the overall length of hospital admissions.

House staff attitudes toward the computer-based educational intervention

All house staff who completed the computer-based intervention in 2009 provided an independent confidential evaluation of the computer-based training upon completion. All PGY levels found the educational intervention to be "very relevant" and the technology interface to be "good"; in addition, most house staff believed the intervention could have been shorter in duration (Table 4).

Discussion

Our study shows that computer-based house staff training could be an effective strategy to improve the knowledge and comfort in the management of diabetes in hospitalized patients. Optimal management of diabetes in hospitalized

Table 4. House Staff Attitudes Toward Educational Intervention

Evaluation question	*PGY-1*	*PGY-2*	*PGY-3*
Relevance of this educational intervention (1 = totally irrelevant to 5 = very relevant)	4.75 ± 0.52	4.81 ± 0.44	4.61 ± 0.70
Technological implantation of this educational intervention (1 = very bad to 5 = very good)	3.93 ± 1.01	3.72 ± 1.12	3.78 ± 1.26
Duration of the educational intervention (1 = too short to 5 = too long)	4.34 ± 0.70	4.34 ± 0.66	4.49 ± 0.60

Results are reported as mean ± SD values.
PGY, postgraduate year.

patients is a recommended goal that is challenging to achieve.[3] Effective methods to increase comfort and knowledge among providers of diabetes management could facilitate the widespread improvement in glucose control for hospitalized patients with diabetes. We observed that a self-conducted computer-based diabetes education curriculum significantly improved the comfort level and knowledge of all internal medicine house staff in managing inpatient diabetes in a large tertiary-care hospital and was generally regarded as a relevant intervention by house staff. Additionally, a trend toward increased use of basal-bolus insulin regimens as opposed to sliding-scale insulin alone was observed, an evidence-based strategy that is endorsed by both the ADA and AACE[3,5,6]; however, this trend did not reach significance.

The value of optimizing glycemic control in critically ill patients has been extensively studied and debated[15,16]; however, poor glucose control in non–critically ill medical patients is also strongly related to adverse outcomes and even mortality.[1,2,17,18] Although there are many deficiencies and obstacles to improving glucose control for medical inpatients,[9] prior studies have provided evidence that the use of sliding-scale insulin alone in non–critically ill hospitalized patients is associated with adverse outcomes,[19] and the use of basal-bolus insulin regimens improves glycemic control and decreases hospital complications compared with the use of sliding-scale insulin alone.[5,6] Preprinted order sets or electronic reminders for basal bolus insulin have been shown to improve glycemic control and are recommended by the AACE/ADA.[4] Therefore, emphasizing the value of using basal-bolus insulin for patients with diabetes admitted to general medical services is important for resident training. Our findings suggest that a well-designed computer-based diabetes management curriculum can be used effectively for this purpose. This curriculum can be distributed broadly to healthcare providers in a tertiary-care center, and this intervention may improve the house staff comfort and knowledge in managing inpatients with diabetes.

The data revealed nonsignificant trends of increased use of basal-bolus insulin strategies and decreased use of sliding-scale insulin alone in the training intervention year. Although these trends could be due to chance alone, it is noteworthy that they were in the direction corresponding with the curriculum of the educational intervention. These trends were not observed in the antecedent year when computer-based diabetes training was not offered. More rigorous educational intervention requiring greater compliance and longer follow-up and larger sample size might increase the power to detect significant changes in clinical outcomes. Future larger and longer studies involving multiple institutes to evaluate the impact of computer-based diabetes training on clinical outcomes are feasible because curricula can easily be distributed to healthcare providers, eliminate the need for rigid education schedules, and offer the flexibility of multiple short sessions that can be accommodated by house staff work hour requirements.

Our study has several important implications related to house staff education as well as the management of diabetes. The use of a computer-based intervention is a novel and contemporary platform for education and allows standardized dissemination of knowledge. This strategy may reduce the amount of effort required to educate and train a broad audience and may represent an effective method to influence a large audience on a focused topic. The strategy can be exploited by hospitals to improve the overall management of diabetes. It may also be useful to improve the management of other disease conditions. Our study expands data from other similar studies that focused on resident physicians to improve the management of diabetes in hospitalized patients.[20–22] In addition, our observations stem from the largest and most comprehensive study to train house staff and evaluated the impact of training on glycemic outcomes in comparison with previous years. Previous studies used a combination of classroom and computer-based teaching and did not include a control group for comparison.[20]

Our findings must be interpreted in the context of our study design. This was a nonrandomized and unblinded study; however, we did use retrospective data to reflect house staff management decisions from the antecedent year, in the same time frame, and in the same tertiary-care hospital and medical wards. All the patients included in this study were managed by a resident/intern under supervision of an attending physician. Although many factors, including different approaches between physicians or other unidentified factors, could have affected our results, there were no known educational/quality improvement projects that happened during 2008 and 2009. We excluded intensive care unit patients because of the changing trends for glycemic control in these patients since publication of the Normoglycemia in Intensive Care Evaluation—Survival Using Glucose Algorithm Regulation (NICE-SUGAR) trial.[15] Although we observed significant changes in house staff knowledge of diabetes management, we detected no change in the incidence of hyper- or hypoglycemia and no significant changes in the use of insulin prescribing practices. The short duration of our assessment periods, as well as our limited sample size of patients and house staff, may have contributed to the lack of statistical significance in these clinical outcomes. Wider implementation of the training program in academic medical centers may be able to show significant improvements in clinical outcomes. Although we analyzed a retrospective comparison group of house staff to reflect the management of diabetes among house staff who were naive to an educational intervention, we did not have intra-individual questionnaire information on the house staff to compare comfort levels over time. Although the dissemination of a computer-based diabetes education curriculum is relatively simple, designing an effective and accurate curriculum and ensuring its successful completion by the target audience are more laborious tasks. The availability of numerous experts in the field of diabetes and the sound organization and infrastructure of our institution were significant advantages in our implementation of such a study.

We conclude that the design and implementation of a computer-based diabetes education curriculum are appreciated and can improve the comfort and knowledge of diabetes management for house staff providers in major academic centers. Whether this intervention will impact insulin administration practices in favor of recommended guidelines remains to be proven.

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Author Disclosure Statement

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Appendix 1

Table A1. Questionnaire to Evaluate Trainees' Comfort Level in Managing Diabetes

How comfortable are you with treating a patient in diabetic ketoacidosis?
What is your comfort level with ordering the right diet for a patient with diabetes?
How comfortable are you with treating a patient with type 2 diabetes whose status is "nothing by mouth" (NPO)?
What is your comfort level with managing a patient with type 1 diabetes in the hospital?
How comfortable are you with discharging a patient with newly diagnosed diabetes from the hospital?
What is your comfort level with starting a patient in the Intensive Care Unit on an insulin drip?
How comfortable are you with converting a patient from an insulin drip to subcutaneous insulin?
How comfortable are you with starting insulin for a patient who previously had not required insulin treatment?
How comfortable are you with diagnosing and treating hypoglycemia?

The provided answers ranged on a scale of 1–5 as follows: 5 = completely comfortable; 4 = somewhat comfortable; 3 = so-so; 2 = somewhat comfortable; 1 = completely uncomfortable.

Appendix 2

Table A2. Questionnaire to Evaluate Trainees' Knowledge in Treating Diabetes

1.	The upper limit for blood glucose range after meals set by AACE, ADA, and JCAHO for hospitalized patients on the wards is:
2.	According to the ADA, which of these blood glucose levels is good for a patient in the ICU?
3.	A patient with type 1 diabetes whose status is "nothing by mouth" (NPO) should:
4.	Which of these is a basal insulin that has an effect of approximately 24 after injection?
5.	Hypoglycemia resulting from "insulin stacking" would be most likely with which of the following insulin regimens:
6.	A diabetes patient being treated with antihyperglycemic agents complains of hypoglycemic symptoms. His fingerstick glucose is 75 mg/dL. This may be explained by all of the following except:
7.	The blood glucose that best guides titration of basal insulin is:
8.	The blood glucose that may help titrate mealtime insulin for the dinner meal (and is also a surrogate for postprandial glucose) is:
9.	When deciding how much to titrate insulin in a patient who is not at glycemic goal (and is not in diabetic ketoacidosis, hyperosmolar nonketotic state), a good rule of thumb is to go up by:
10.	When a patient with diabetes is admitted to the hospital, which of the following information should be gathered to help optimize glycemic control and avoid hypoglycemia?
11.	In the hospital setting, when titrating insulin, which of the below pieces of history or data are relevant to managing diabetes?
12.	Which of these foods do not contain carbohydrates?
13.	What do you do with a patient with type 1 diabetes who comes in on an insulin pump?
14.	The following is true in diabetic ketoacidosis:
15.	The following is true about hospitalized pregnant patients with type 1 diabetes:
16.	Which of the following is NOT true of hospitalized patients with new-onset type 2 diabetes?
17.	What is the appropriate management for a patient with type 1 diabetes who is on intravenous insulin, has closed the anion gap, and is ready to eat?
18.	What do you need to do to order intravenous insulin in the ICU setting?
19.	An obese patient with type 2 diabetes is admitted to the hospital with pneumonia. You are entering admission orders. What is the right diet order for this patient?
20.	All the following statements about oral antidiabetes agents in the hospital are correct except?
21.	An 80-year-old lady with type 2 diabetes is admitted after a syncope. She weighs 60 kg (132 lbs) and has a normal body mass index of 21 kg/m^2. What is a good initial diet order for this patient?
22.	You are called about hypoglycemia on a patient in the Rehab Unit. The patient is a 78-year-old man who had been doing well up until he developed nausea and decreased appetite. His blood sugars have been running 48–72 mg/dL. Which of the following medications should be stopped or decreased in dose when someone's oral intake is expected to decrease?
23.	A patient in the ICU has been on an insulin drip overnight and is ready to be transferred to the wards. The patient has been on a D5 drip and is hungry. It's 8 a.m. now. Here's the flowsheet with how much insulin the patient has been receiving per hour. The blood glucose has been at target: 1 a.m., 3 units/h; 2 a.m., 2 units/h; 3 a.m., 2 units/h; 4 a.m., 1.5 units/h; 5 a.m., 2.5 units/h; 6 a.m., 2 units/h; 7 a.m., 2 units/h. You order insulin glargine and insulin aspart, since he is about to eat. What is a good starting dose for his insulin glargine?

AACE, American Association of Clinical Endocrinologists; ADA, American Diabetes Association; JCAHO, Joint Commission on Accreditation of Healthcare Organizations; ICU, intensive care unit.

Table A3. Answer Key for Knowledge Questions

Question number	Answer choices 1–5					Correct answer
	1	2	3	4	5	
1.	80 mg/dL	110 mg/dL	180 mg/dL	200 mg/dL		3
2.	88 mg/dL	143 mg/dL	189 mg/dL	243 mg/dL		2
3.	Receive the usual standing basal and rapid-acting insulin	Receive the usual dose of basal insulin	Not receive any insulin, because they are "nothing by mouth"	Not receive standing insulin, because they are "nothing by mouth," but should be covered by regular insulin sliding scale		2
4.	Aspart	Glargine	NPH	Regular insulin		2
5.	Regular insulin IV q3h	Regular insulin SC q3h	Aspart SC q3h	Aspart with meals		2
6.	His blood sugar is falling rapidly	The glucometer glucose is not accurate	He has developed hypoglycemia unawareness			3
7.	Bedtime glucose	Fasting/AM glucose	Pre-lunch glucose	2-h postprandial blood glucose	Peak blood glucose	2
8.	Bedtime glucose	Pre-dinner glucose	Fasting/AM glucose	Pre-lunch glucose	Peak blood glucose	1
9.	5 –10% total daily insulin	10–20% total daily insulin	20–40% total daily insulin	Whatever feels right	Never more than 2 units at a time because we want to avoid hypoglycemia	2
10.	Type 1 or type 2 diabetes	Medications at home, including insulin and doses	Hemoglobin A1c	Blood glucose range	All of the above	5
11.	Blood glucoses	Oral intake	Glucotoxic medications (steroids)	Actual insulin administered by the nurse	All of the above	5
12.	Peanut butter	Eggs and bacon	Chili	Sugar-free chocolate	Plain low-fat yogurt	2
13.	Always take the patient off the pump	Assess whether the patient is capable of using his or her pump	Always leave the patient on the pump	Ask the medical student with the cool phone to program the pump	Leave the patient on the pump and also start aspart and glargine insulin as a backup	2
14.	Fluid should be given gingerly to avoid CHF	K repletion should start when the K is in the high-normal range	By definition, every patient with DKA has type 1 diabetes	Insulin should be given subcutaneously to avoid hypoglycemia associated with IV insulin	Insulin drip must be stopped as soon as the anion gap is closed	3
15.	Always use basal-bolus insulin with glargine and aspart	Their blood glucose level targets are higher because hypoglycemia is very dangerous in pregnancy	Pregnant patients never get admitted to the medical wards	They should have their blood glucose monitored very closely, as frequently as 8–10 times daily	They should only be managed with IV insulin	4

(*continued*)

Table A3. (Continued)

Question number	Answer choices 1–5					Correct answer
	1	2	3	4	5	
16.	They can be managed with a combination of long-acting and mealtime insulin	Insulin can be titrated on a daily basis about 10–20% at a time until their blood sugars are controlled	They should be treated with regular insulin sliding scale only	A reasonable starting dose of basal insulin is 0.2 units/kg		3
17.	Stop the insulin drip and start glargine and aspart a few hours later after ascertaining that the patient doesn't have a low blood sugar	Start glargine insulin, discontinue the drip about 2–3 h later, and give aspart with meals	Increase the insulin drip rate and start glargine and aspart in order to make sure the patient receives an adequate dose of insulin	Stop the insulin drip and write for an aspart sliding scale	Start NPH q4h	2
18.	Calculate the initial infusion rate, measure blood glucose every hour, and enter an order for a new infusion rate every hour	Give the order for insulin infusion according to the ICU protocol and tell the nurse about it.	Nothing. The diabetes team takes care of all the patients with diabetes in the ICU			2
19.	Regular diet	800 kcal diet	1,800 kcal diet, no concentrated sweets	Carb-controlled 800 kcal diet, no concentrated sweets	Carb-controlled 1,800 kcal diet, no concentrated sweets	5
20.	Glyburide is a great choice for elderly patients or patients with renal insufficiency	They might lead to lactic acidosis in patients undergoing radiologic studies with contrast dye or elderly patients	Patients in the hospital may have strong variations in the food intake or renal function	TZDs such as pioglitazone or rosiglitazone can cause fluid retention on patients with CHF	They can lead to hypoglycemia, and the hypoglycemic events can return even after treatment with D50	1
21.	Carb-controlled diet, 800 kcal/day, no concentrated sweets	Carb-controlled diet, 1,500 kcal/day, no concentrated sweets	Carb-controlled diet, 2,000 kcal/day, no concentrated sweets	Carb-controlled diet, 2,500 kcal/day, no concentrated sweets	Carb-controlled diet, 3,000 kcal/day, no concentrated sweets	2
22.	Glipizide	Metformin	Pioglitazone	Repaglinide	Glipizide and repaglinide	5
23.	8 units	12 units	20 units	30 units	48 units	3

Carb, carbohydrate; CHF, chronic heart failure; DKA, diabetic ketoacidosis; ICU, intensive care unit; IV, intravenous; K, potassium; NPH, neutral protamine Hagedorn; SC, subcutaneous; TZD, thiazolidinedione.