

Knowledge on Inpatient Diabetes Among Fourth-Year Medical Students

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OBJECTIVE — The importance of proper management of inpatient hyperglycemia is increasingly being recognized. However, the curriculum for 4th-year medical students has lagged behind current clinical recommendations. The aim of this study was to assess the baseline knowledge of medical subinterns on inpatient diabetes.

RESEARCH DESIGN AND METHODS — In the 2005–2006 school year, subinterns were given a pretest on inpatient diabetes. Descriptive analysis was used.

RESULTS — Students frequently recommended the sole use of sliding scale for diabetes management. Hyperglycemia in patients not known to have diabetes is less likely to be recognized. The students were more likely to provide appropriate management for chest pain than diabetes. Students were otherwise knowledgeable about the recognition of type of diabetes and the pharmacology of the medications.

CONCLUSIONS — This study demonstrates the gaps in knowledge about inpatient diabetes that exist before internship and residency. The findings can be used to design a curriculum appropriately targeted to the level of 4th-year medical students.

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Inpatient diabetes causes significant morbidity, mortality, and length and cost of hospital stay. It is often neglected because the majority of patients with diabetes are admitted for medical conditions other than diabetes. In the past decade, observational studies demonstrated increased morbidity, mortality, and length and cost of hospital stay in hyperglycemic patients, while interventional studies in the intensive care setting showed that tight glucose control improves these outcomes. Consequently, there is a movement to improve glycemic control in patients admitted to the hospital, whether they have newly recognized hyperglycemia or known diabetes. Published guidelines for inpatient management are a product of this movement, and they emphasize proper insulin administration. However, up until 2004, a national medical curriculum for subinterns

(4th-year medical students) still promoted the “ability to develop a sliding scale plan for inpatients” as a major learning objective (1).

Consequently, here we target a program that teaches inpatient diabetes management to 4th-year medical students. As future house officers, they are at the front-line of inpatient diabetes management, yet most residencies apart from internal medicine and pediatrics do not emphasize this topic. This study was undertaken to assess the baseline knowledge of medical subinterns on inpatient diabetes. By so doing, we could subsequently reexamine the 4th-year medical student curriculum and design one that is more appropriately targeted to their level. This would hopefully prompt other institutions, if they have not already done so, to perform a similar redesign of their subinternship program.

RESEARCH DESIGN AND METHODS

The study was conducted at the University of Florida (Gainesville, FL). During the 2005–2006 academic year, subinterns rotating each month in internal medicine were asked to complete a pretest that included cases and questions on the recognition and management of inpatient diabetes. The pretest comprised six question sets: two were case scenarios with open-ended questions as described below, and the remaining four were multiple choice and matching-type questions. The open-ended question sets were designed to be broad, encompassing not only diabetes but also the management of other medical conditions such as hypertension, chest pain, and chronic obstructive pulmonary disease in hospitalized patients to minimize bias that could occur if students recognized that diabetes knowledge was the area of interest. The students were not restricted in their methods of obtaining proper responses, and they were given at least 2 days to complete the pretest.

The two clinical scenarios consisted of patients presenting to the hospital with a problem unrelated to diabetes but who also had diabetes management issues. Students were asked to identify the major medical problems (one of which was diabetes in each case) and generate an initial plan for the treatment of each of the identified problems. Case scenario 1 was a 50-year-old female admitted because of left-sided chest pain with exertion, and she had a history of type 2 diabetes and hypertension. She was on low-dose Amaryl and lisinopril, as well as maximum-dose metformin. On exam, she was hypertensive and obese. Serum creatinine was 1.8 mg/dl. The students were provided with premeal and bedtime inpatient capillary blood glucose levels for the previous 2 days, ranging from 177 to 300 mg/dl.

Briefly, case scenario 2 was an adult patient with exacerbation of chronic obstructive pulmonary disease who was on chronic intermittent steroid intake. He had a history of hypertension and no previous diagnosis of diabetes. He was given high-dose steroids and had an elevated random plasma glucose in the hospital. Three additional capillary blood glucoses taken before meals and at bedtime, rang-

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A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

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Table 1—Number of students who identified the medical problems and gave an appropriate initial plan in case scenario 1

	Correctly identified as problem	Gave appropriate initial plan	P value (appropriate initial plan compared with diabetes)
Diabetes	52 (100)	35 (67)*	—
Chest pain	52 (100)	52 (100)	<0.001
Hypertension	52 (100)	50 (96)	0.001
Obesity	44 (85)	43 (98)	0.001
Elevated creatinine	51 (98)	43 (84)	<0.05

Data are n (%). *Decreased to 24 of 52 (46%) when given more blood glucose readings.

ing from 180 to 270 mg/dl, were subsequently provided to the students. The students were then asked to give new plans based on these.

The next four multiple-choice and matching-type questions assessed students' knowledge and covered hyperglycemia management during hospitalization, the time profiles of the different types of insulin, mechanism of action of oral medications, and recognition and initial management of type 1 versus type 2 diabetes.

Responses to the pretest were collected during the 2nd week of the rotation. One adult endocrinologist debriefed the students during a 1-hour, primarily didactic teaching session about inpatient diabetes. This study was approved by our institutional review board.

At this tertiary academic medical center, all students are required to complete a 1-month subinternship in internal medicine, pediatrics, or family medicine. During their pediatrics rotation, they have a 1-hour case conference on endocrinology, with one of the cases being new-onset type 1 diabetes. During their family medicine rotation, students undergo a 2-h case conference on diabetes, in which they are told that sliding-scale insulin is an antiquated approach to the management of diabetes. Approximately two-thirds of each class selects the internal medicine subinternship, which is entirely inpatient and experiential. Inpatient diabetes teaching is largely dependent on the attendings assigned to the internal medicine teams. There are three general internal medicine services, two hospitalist services, and several subspecialty services (e.g., cardiology, hematology-oncology). Three adult endocrinologists serve as attendings for a combined total of 4 months per school year on one of the general internal medicine teams, during which time the subinterns rotating with them receive a more detailed teaching of inpatient diabetes. Otherwise, most of the students'

exposure to inpatient diabetes is limited to cursory discussions on adjusting insulin doses on the general medical floors. Students are evaluated solely by their ward teams using a competency-based evaluation form with descriptive anchors. There is no written exam (except for the pretest described above). Students are expected to manage a similar number of patients as an intern and are responsible for writing all patient orders under the close supervision of a junior or senior resident, who also signs the orders.

Our a priori hypotheses were 1) that sole sliding-scale insulin would be the most common treatment plan for diabetes, 2) that newly detected hyperglycemia will not be recognized as a problem as often as previously diagnosed diabetes, and that 3) subinterns are more familiar with the initial management of an acute problem such as chest pain than the inpatient management of diabetes, which is considered a chronic disease. Responses were deidentified. The pretest was developed by the authors (one of whom is a general internal medicine physician and master educator and the other an adult endocrinologist) after assessing existing practices in the hospital through chart reviews and extensive interaction with the house staff. Other disease states such as hypertension, obesity, and renal dysfunction were added so that the true focus of the pretest was masked from the students. The master educator ensured that the questions were appropriate for the level of the subinterns. Appropriateness of the treatment plans was determined by a consensus between the authors before tabulation of results and was based on clinical experience and review of the literature. Statistical analysis was performed using χ^2 test.

RESULTS— Fifty-two subinterns completed the pretest. For the open-ended clinical scenarios, all 52 students

identified a known diagnosis of diabetes as a problem, whereas only 47 of 52 students recognized hyperglycemia in a patient without known diabetes as a problem ($P = 0.025$). The number of students who identified the other problems correctly for case scenario 1, as well as those who gave the appropriate initial management, is shown in Table 1.

Compared with other medical conditions such as chest pain or hypertension, students were less apt to give appropriate management for diabetes. Seventeen of 52 students wrote inappropriate initial management plans, including 16 who indicated sole use of sliding-scale insulin and 1 who increased the dose of metformin. Ten of 52 students recognized the need to initiate a long- or intermediate-acting form of insulin, 8 of 52 either increased the glimepiride dose or added another oral hypoglycemic agent, and 17 of 52 suggested insulin as a therapy but did not specify the type. Interestingly, when subsequently asked to write their orders for managing this hypothetical patient's diabetes, 11 of the 36 students who did not initially suggest sliding-scale insulin actually indicated sole use of sliding-scale insulin as the sole pharmacologic management instead of their previous answers. In addition, only 9 of the 52 students recognized the need to stop metformin because of an elevated creatinine level.

Appropriate initial management was given more commonly for chest pain than for diabetes ($P < 0.001$; Table 1). For chest pain, the following were considered appropriate (with the number of responders in parentheses; $n = 52$ total): obtain an electrocardiogram or cardiac enzymes ($n = 10$), obtain an electrocardiogram and cardiac enzymes ($n = 35$), administer nitroglycerin ($n = 2$), and stress test if the patient is stable ($n = 5$). For hypertension, the following were considered appropriate ($n = 50$ of 52): add a β -blocker

Table 2—Management for case scenario 2 before and after three additional hyperglycemic values were provided

Management plan	Initial management (n)	Management after three additional hyperglycemic values (n)
Total	47	52
Sliding scale alone	16	22
Long- or intermediate-acting insulin, with or without mealtime insulin	1	14
Oral agents	8	4
Obtain more glucose values	16	6
No answer	0	4
Others (diet, unspecified insulin, taper steroids)	6	2

(n = 19), add a diuretic (n = 11), increase lisinopril (n = 16), add another antihypertensive medication (no medication specified; n = 3), and low-sodium diet (n = 1). Two students simply said to continue the current medication, which we considered inappropriate since they did not specify that they wanted a recheck of blood pressure. For obesity, 43 of 44 students responded appropriately, recommending education or counseling on weight loss and exercise (n = 32) and prescribing dietary modifications (n = 11). One answered inappropriately, suggesting to simply monitor for fluid retention. For the elevated creatinine levels, 43 of 51 gave appropriate recommendations, including obtaining a full basic metabolic panel or at least blood urea nitrogen (n = 12), comparing first with previous creatinine levels (n = 11), repeating creatinine levels or calculating creatinine clearance (n = 10), discontinuing metformin (n = 5), checking a urinalysis (n = 2), giving fluids if the calculations show prerenal problems (n = 2), increasing ACE inhibition for renoprotection (n = 1), and monitoring input and output (n = 1). The following was considered inappropriate: administering fluids (without checking to see if this is prerenal; n = 7).

In case scenario 2 (patient without known diabetes), the predominant management also consisted of sliding-scale insulin alone, even after indicating that the patient subsequently had three more elevated glucose levels (Table 2).

Students scored an average of 81% on the multiple-choice and matching-type questions that assessed ability to recognize type of diabetes and the pharmacology of the medications. However, students scored markedly lower on the one multiple-choice question that ad-

ressed management of hyperglycemia, with only 54% answering correctly and 46% incorrectly selecting sliding-scale insulin as the best treatment plan.

Responses did not differ between students rotating early versus late in their 4th year in terms of prescribing sliding scale as the sole initial management for the patient in case scenario 1 (7 of 25 in the earlier groups and 9 of 27 in the later groups; P = NS).

CONCLUSIONS— Our study demonstrates that gaps in knowledge regarding inpatient diabetes exist before internship and residency. Most striking is the inappropriate use of sliding-scale insulin without scheduled insulin. The other major finding is that students fail to apply theoretical knowledge into practice (e.g., they know the time profile of the different insulins yet cannot translate that into meaningful order entries). Other less striking but notable knowledge gaps include failure to recognize hyperglycemia as a problem in patients without a previous diagnosis of diabetes and failure to recognize medication contraindications. Students were able to make more appropriate recommendations for other medical problems such as chest pain, which supports a need for targeted education about diabetes.

Diabetes is a common inpatient diagnosis. In 2004, ~20% of hospitalized adult patients at the University of Florida and Shands had a diagnosis of diabetes, with probably 5% more being undiagnosed based on the literature (2–4). Inpatient hyperglycemia increases inpatient morbidity, mortality, and length and cost of hospital stay (5–7), yet is frequently left unattended since it is usually not the patients' chief complaint (4,8). Because of

the compelling evidence for better glycemic control in the hospital, guidelines for target blood glucoses have been released that aim for a preprandial glucose value of 110 mg/dl and maximal glucose levels of 180 mg/dl in non-critical care units (3).

A major finding in this study is that the overuse of sliding-scale insulin already exists during subinternship. Even though the source of the students' knowledge was not formally tested, frequent interactions with them reveal that this is most likely handed down by interns, residents, and attendings. In one study at our tertiary academic medical center, a common cause of inpatient hyperglycemia was the sole use of sliding-scale insulin to manage diabetes (9). The sliding-scale method has been shown in several studies to be ineffective (10,11), yet this practice has been passed down over decades. Moreover, insulin is a common source of medication error (12,13), and proper education is needed to prescribe the proper type and dose. However, reeducation on this topic has been challenging. One study on educating house staff on the use of proactive insulin treatment instead of sliding-scale insulin did not meet with success (14). Lately, one method that was more effective required one endocrinologist to round with two residents twice a day, at 7:00 A.M. and 6:00 P.M. for 2 weeks at a time (15). Though the effort is admirable, not all programs have the necessary dedicated faculty members to carry out this task. Moreover, it seems logical that this teaching should be done earlier, at the time of the medical students' exposure to the hospital wards, before these would-be interns start taking care of their own patients.

The recognition that diabetes is a problem is important for resource allocation and proper management. In a study comparing diagnoses of hospitalized patients, the diagnosis of diabetes was omitted in 47–88% of discharge diagnoses (16). The percentage of admissions and bed occupancy accounted for by diabetic patients was underestimated: only half of the diabetic patients admitted were coded as such. In another study of hospitalized patients with hyperglycemia but no previous diagnosis of diabetes, 66% of the progress notes failed to mention either diabetes or hyperglycemia as a problem (4). In our study, all of the students recognized diabetes as a problem when the diagnosis was given to them but did not necessarily do so when presented with a hyperglycemic patient without known di-

abetes. Even in this test setting in which students were prompted to list five medical problems, they still failed to recognize hyperglycemia more often than any other problem except obesity (which arguably is not an acute hospital problem). This is consistent with the underrecognition of diabetes and hyperglycemia in the hospital setting and makes it a clear target for future educational interventions.

The students have a good fund of theoretical knowledge, with most of them being familiar with the time-action profile of insulin and mechanism of action of oral medications. However, most of them are still unable to translate this into practice; most of them still chose to prescribe sliding-scale insulin in different case scenarios. The subinternship is one of the first times in medical training that students are given independent (though supervised) responsibility for patient care. This makes these application deficits more apparent but also makes the 4th year an ideal time to promote education about patient management.

Until the beginning of 2005, the subintern curriculum set by the Alliance for Academic Internal Medicine included, as a learning objective for inpatient diabetes, the development of a sliding scale plan for the patients (1). This clearly lagged behind the recommendations of experts to institute basal and nutritional insulin for inpatient glycemic control (3,17). Diabetes was also considered a chronic condition for which management remained in the outpatient realm. In the second half of 2005, the learning objectives for the subintern curriculum were revised; sliding scales were supplanted by the need to address basal and nutritional insulin requirements. The management of diabetes in the hospital was given more attention and not relegated solely to the outpatient setting.

We acknowledge the fact that our study was done in a nonclinical setting, i.e., students were asked to answer questions presented in a test format rather than analyzing patients that they have seen, and this might affect construct validity. However, we attempted to present them with scenarios that resemble true inpatient cases. The students were also in their 1st week of internal medicine rotation and could potentially have learned appropriate diabetes inpatient management in the succeeding weeks. However,

we know from our extensive interactions with house staff that this is not likely to occur without formal teaching. We addressed content validity by including several aspects of inpatient diabetes knowledge, including mechanism of action of oral medications, action profiles of different insulins, and formulation of treatment plans, with more emphasis on the latter because the medical students are in their clinical rotations at this stage. However, this pretest was not intended to be exhaustive but meant to touch on the more common situations that the subinterns were going to encounter.

Another limitation is that our study was performed with a small sample size and in a single institution in Florida, such that our results may not be generalizable. However, we know from our contacts with colleagues during national meetings that our experience is not unique. Our study might prompt a more systematic evaluation of other institutions' curricula for subinterns.

We believe that inpatient diabetes management should be taught prior to internship and residency. This study has provided us with baseline information that can be used for our educational program for subinterns.

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