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ORIGINAL ARTICLE

Hemoglobin A1c Testing in an Emergency Department

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Abstract

Background:

Emergency department (ED) visits for hyperglycemia are common and costly. Enhanced strategies for recognizing and managing patients with diabetes in the ED are needed. Hemoglobin A1c (A1C) testing is typically used to assess level of glycemic control in the 2–3 months preceding an office visit. In this article, we report on potential roles for point-of-care (POC) A1C testing in the ED for patients presenting with uncontrolled hyperglycemia.

Methods:

We enrolled patients presenting to an urban tertiary care hospital ED with blood glucose (BG) ≥200 mg/dl who were otherwise stable for discharge (n = 86) in a prospective, nonrandomized pilot study. Antihyperglycemic medication management, survival-skills diabetes self-management education, and health system navigation were provided. Followup visits took place at 24–72 hours and at 2 and 4 weeks. Point-of-care A1C testing was performed at baseline and at 2 weeks. Baseline A1C results were used by the ED physician and the educator to inform the patient of likely preadmission glycemic classification, and the potential role that the (diabetes mellitus) DM medication regimen assigned in the ED had in enabling overall progress in glycemic control at 2 weeks post-ED initiation of treatment.

Results:

At baseline, 50% of POC A1C values were >13%. Mean BG fell from 356 ± 110 mg/dl to 183 ± 103 mg/dl at 4 weeks (average decrease of 173.5 g/dl, $p < 0.001$). Mean A1C fell by 0.4%, from 12.0 ± 1.5% to 11.6 ± 1.6% at 2 weeks, $p = 0.048$. There were zero instances of day 1 hypoglycemia and overall hypoglycemia rates were low (1.3%).

Conclusions:

Point-of-care A1C testing in the ED helped inform both the provider and the patient of likely prior glycemic status, including unrecognized or uncontrolled type 2 diabetes, and allowed emphasis of the importance of timely diabetes self-management education and medication management in preventing acute and chronic complications. Followup POC A1C testing at 2 weeks was used to confirm early improvement in glycemic control postintervention.

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Abbreviations: (A1C) glycosylated hemoglobin, (ADA) American Diabetes Association, (BG) blood glucose, (DM) diabetes mellitus, (DSME) diabetes self-management education, (eAG) estimated average glucose, (ED) emergency department, (POC) point of care, (T2DM) type 2 diabetes mellitus

Keywords: A1C, diagnosis, emergency department, hyperglycemia, type 2 diabetes

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Introduction

Emergency department (ED) visits for uncontrolled diabetes mellitus (DM) inflict a significant burden on the health care system. In the District of Columbia, 39,857 DM-related ED visits per year incur costs of approximately $27 million.[1] Each such visit typically accrues charges of $678 in the Washington Hospital Center according to ED data. Hyperglycemic patients presenting to the ED may have a known diagnosis of DM, previously unrecognized DM, pre-DM or stress/illness-related hyperglycemia.

Ginde and colleagues[2] have reported that recognition, communication, and management of hyperglycemia in the ED are suboptimal. The ED offers an opportunity to identify patients with suboptimally controlled DM, previously unrecognized DM, and/or those who may have pre-DM. Their identification, in turn, will allow initiation of appropriate lifestyle and/or medication management and DM self-management education (DSME) to enable glycemic control, prevent recurrent ED visits for uncontrolled hyperglycemia, and prevent long-term DM complications. Strategies for recognizing and managing patients with or at risk for DM in the ED are needed.

Laboratory hemoglobin A1c (A1C) may be used to establish a diagnosis of DM or pre-DM and/or to assess status of glycemic control in the 2–3 months preceding performance of the assay. Hemoglobin A1c testing using clinical laboratory equipment has been incorporated by the American Diabetes Association (ADA) and a 2009 International Expert Committee[3] as a diagnostic criteria for type 2 diabetes mellitus (T2DM) (>6.5%) and for pre-DM (5.7–6.4%). The international A1C derived Average Glucose Trial correlated laboratory A1C with mean plasma glucose to provide an estimated average glucose (eAG).[4] Point-of-care (POC) A1C testing allows for immediate availability of A1C measurements, a determination of eAG in the months prior to the test being performed, thus facilitating DM management at the time of a patient visit.

Diagnostic criteria for DM and pre-DM presenting to the ED have not been established. There are, however, some reports related to the potential for their detection at the time of ED visits in at-risk patients.[5,6] Utility of POC A1C testing for opportunistic screening in the ED has been suggested as a tool to determine if outpatient testing is warranted to fully establish glucose tolerance status.[6]

This article describes potential roles for POC A1C testing in the management of patients presenting to the ED with uncontrolled hyperglycemia. Based on the utility of A1C in assessing long-term glycemic control in the 2–3 months prior to the test being performed and the availability of outpatient criteria for the diagnosis of pre-DM and DM,[3] this test may be considered for use both as an adjunct to confirm a new diagnosis of diabetes and/or to make the case for initiation and/or intensification of antihyperglycemic medication, particularly insulin, and lifestyle management. Hemoglobin A1c may also be considered for a role in the early assessment of the impact of the management regimen on overall glycemic control.

Study Description

We conducted a prospective, nonrandomized pilot study, the Synergy to Reduce Emergency Department Visits Project for the District of Columbia (STEP-DC), to examine the safety and preliminary efficacy of a multidisciplinary team intervention for managing uncontrolled T2DM presenting to the ED. (Manuscript under review by Journal of the National Medical Association.) The protocol was approved by the MedStar Health Research Institute Institutional Review Board. All participants provided informed consent. Patients presenting to an urban tertiary care hospital ED with blood glucose (BG) ≥ 200 mg/dl who were otherwise stable for discharge (n = 86) were enrolled in the study. An antihyperglycemic medication algorithm using sulfonylureas, metformin and/or insulin (**Table 1**) guided pharmacotherapeutic management, and survival-skills diabetes self-management education and health system navigation support were provided. Followup visits took place at 24–72 hours and at 2 and 4 weeks following the ED visit. A final visit was conducted at 6 months. No hypoglycemia was observed in the first 24 hours following initial ED medication management per our algorithm. Hemoglobin A1c was reduced by 0.4% at 4 weeks and mean BG was reduced by 174 mg/dl. A trend for reduction in ED visits for uncontrolled T2DM was observed compared with historic self-controls.

We hereby report details of our methodology and our observations relative to A1C-NOW+ point-of-care (POC) testing in this small cohort of ED patients. Two cases from the study are also presented, which illustrate the potential for POC A1C testing to be of utility in the ED

Table 1.
STEP-DC Guidelines for Emergency Department Hyperglycemia Discharge Management

No Prior Anti-Hyperglycemic Agent Therapy

BG (mg/dl)	Action	Definitions/Diagnostic criteria
126–139 (fasting)	Follow-up BG with MD within 2 weeks. BG is not completely normal. Possible diabetes (DM) or pre-DM.	Prediabetes: -Fasting BG 100–125 mg/dl -or 2-hour 75 gm OGTT ≥140 mg/dl Diabetes: -Fasting BG ≥126 mg/dl × 2 days -or Casual plasma glucose ≥200 mg/dl with symptoms of hyperglycemia -or 2-hour 75 gm OGTT ≥200 mg/dl
140–199 (random)	Follow-up BG with MD within 2 weeks. Sooner if symptoms of hyperglycemia. Probable diagnosis of DM or pre-DM.	
200–250	Inform patient of diabetes diagnosis Start metformin 500 mg po bid OR low-dose sulfonylurea if metformin contraindicated	
251–300	Metformin 500 mg po bid PLUS starting dose sulfonylurea OR basal insulin: glargine (or detemir) 10 units SQ once daily OR NPH (or 70/30) 5 units twice daily (with breakfast and dinner)	
301–350	Correction dose of rapid-acting insulin analog in ED Basal insulin: glargine (or detemir) 10 units SQ once daily. First dose given in ED. May use NPH, but split dose to bid	
350–400	Correction dose of rapid-acting insulin analog in ED (see algorithm page 2) Basal insulin: glargine (or detemir) 0.2 units/kg/day. First dose given in ED May use NPH, but split dose to bid	
>400	Treat with IV fluids and correction dose of rapid-acting insulin analog. Observe for 2–4 hours. If patient responds with a decrease in BG, start basal insulin as above for BG 350–400	

Preexisting Diabetes on Oral Antihyperglycemic Agents

BG (mg/dl)	One agent			2–3 oral agents
	On metformin	On sulfonylurea	On other agent	
80–139	No change. Follow up with MD.			
140–199	<1000 mg daily: Titrate dose upward >1000 mg daily: Add sulfonylurea	Add metformin OR titrate sulfonylurea dose upward	Add metformin (or sulfonylurea if metformin contraindicated)	Titrate to higher or maximal dose(s)
200–300	Titrate to higher or maximal dose AND/OR add second agent OR add basal insulin: glargine (or detemir) 10 units SQ daily If not already on metformin, add 500 mg po bid			Basal insulin: glargine (or detemir) 0.2 units/kg/day If not already on metformin, add 500 mg po bid Discontinue third agent
301–400	Correction dose of insulin in ED basal insulin: glargine (or detemir) 0.2 units/kg/day If not already on Metformin, add 500 mg po bid			
>400	Treat with IV fluids and correction dose of rapid-acting insulin analog in ED 2 Observe for 2–4 hours. If patient responds, start basal insulin as above			

Preexisting Diabetes on Insulin (With or Without Oral Agents)

BG (mg/dl)	Action
Fasting >120 (morning)	Increase basal dose (daily glargine/detemir or evening dose of NPH) by 10% If patient is on a premixed regimen (70/30), increase predinner dose by 10%
Premeal >140 (lunch, dinner)	-Increase glargine or detemir dose by 10% IF a.m. fasting BG is also elevated—UNLESS overnight hypoglycemia is suspected (history of insomnia, night sweats, nightmares), in which case: decrease basal glargine dose by 10–20% -Increase A.M. dose of NPH or premixed insulin by 10–20% -Decrease evening doses of NPH or premixed IF overnight hypoglycemia is suspected (see above) or fasting hypoglycemia is present

(SQ) subcutaneous, (NPH) neutral protamine Hagedorn

setting in the management of T2DM patients presenting with uncontrolled hyperglycemia.

Methods

Hemoglobin A1c was measured using the A1C-NOW+® device (Bayer Healthcare Diabetes Care, Sunnyvale, CA). The upper limit of the A1C-NOW+ test range is 13%. The POC A1C was measured at the time of the initial visit to the ED with hyperglycemia, and at the 2-week followup visit to an ambulatory care clinic. Hemoglobin A1c level was not specifically included as an actionable feature of the study medication management algorithm, which used presenting BG level and prior antihyperglycemic agent therapy, if any, to guide medication selection for the individual patient. The results of the A1C POC assay were used by the ED physician and the certified diabetes educator team to provide information as to the likely duration and severity of hyperglycemia at the time of presentation, and to support the case for initiating and/or intensifying insulin therapy at the time of the ED visit.

Results

Participants, n = 86, were 92% African American, 51.8% male, and 62% were ages 40–65 years. Eighty-one percent of participants completed visit 2, 67% completed visit 3 where the repeat POC A1C was obtained, and 60% completed all 4 visits.

Glucose and A1C-NOW+ results are shown in **Table 2**. Mean BG fell from 356 ± 110 mg/dl at baseline to 183 ± 103 mg/dl at 4 weeks, representing an average reduction of 173.5 mg/dl, ($p < 0.001$ for paired t-test). There were zero instances of day 1 hypoglycemia and overall hypoglycemia rates were low (1.3%). At baseline, fully 50% of A1C values were >13%. Mean A1C at baseline was 12% ± 1.5%. In the 46 subjects for whom A1C was obtained at baseline and at 2 weeks, A1C had fallen by 0.4% at the 2 week visit to 11.6% ± 1.6% ($p = 0.05$ for Wilcoxon signed rank test).

Details of two patient cases from this study are shown in **Table 3** to provide examples of the potential practical utility of performing A1C POC testing in the ED.

Discussion

Alarmingly, in the United States, approximately 25–33% of patients with T2DM remain undiagnosed.[7,8,9] Changes in glucose concentrations, insulin sensitivity, and insulin secretion may be present for as long as 3–6 years prior to a T2DM diagnosis being made.[10] Furthermore, ED patients have a high prevalence of previously unrecognized DM.[6] The ED therefore provides an opportunity to identify undiagnosed and/or uncontrolled T2DM, particularly in minority and vulnerable populations among whom the ED is often utilized as a safety-net source of medical care.[11]

The ADA recognizes the A1C test as a diagnostic tool, with an A1C level ≥6.5% providing a cut point for the diagnosis of DM and one of 5.7–6.4% being classified as at high risk for diabetes (pre-DM).[3] Hemoglobin A1c testing allows convenience and ease of sample collection. Hemoglobin A1c can be obtained at any time of day and is not sensitive to timing of food intake, requires no patient preparation, and is relatively stable at room temperature. In comparison, fasting plasma glucose testing requires a timed sample taken after at least an 8-hour fast and is relatively less stable at room temperature. These considerations support using the A1C assay to diagnose DM. These diagnostic criteria apply to making a diagnosis of DM or pre-DM in the outpatient setting.

Table 2.
Intervention Impact on Mean Blood Glucose and A1C[a]

	Baseline		Post-intervention		Difference		
Variable	*N*	Mean ± SD	*N*	Mean ± SD	*N*	Mean	*p*-value[d]
Blood glucose	51[b]	356 ± 110 mg/dl	51	183 ± 103 mg/dl	51	174 mg/dl	<0.001
A1C	46[c]	12.0% ± 1.5%	46	11.6% ± 1.6%	46	-0.4%	0.05

SD, standard deviation
[a] At baseline, 50% of the A1C values were >13%, the upper limit of the A1CNow+ test.
[b] Subjects who completed all 4 visits.
[c] Subjects who completed visit 3 (2 weeks) and had pre- and post- A1C test results.
[d] Paired t-test was used to test the differences for blood glucose. Wilcoxon signed-rank test was used to test the differences in A1C distributions.

In the ED setting, a few reports have described screening using random BG and/or A1C for detecting undiagnosed DM and/or prediabetes. Charfen and colleagues found that subjects with two DM risk factors and a random BG >155 mg/dl all had DM or pre-DM on follow-up testing[5]. In another study, 51% of patients in the ED were found to have borderline (5.5–6.0%) and 29% abnormal (≥6.1%) A1C results. Up to 38% of subjects in each of these categories were found to have DM or pre-DM on follow-up testing.[6] Further studies are needed to define the role of BG and A1C testing and to establish criteria for the diagnosis of DM and pre-DM in the ED setting.

Hemoglobin A1c test results traditionally provide an established measure of long-term glycemic control in persons with DM. This article suggests that there may be potential for incorporating A1C results obtained in the ED using the Bayer A1C-NOW+ device to inform the likelihood of a diagnosis of T2DM or pre-DM, the level of control in the 2–3 months preceding the ED visit, and to emphasize the need for initiation and intensification of diabetes medications, including insulin, when previously unrecognized and/or uncontrolled DM was found to be present.

The POC A1C provided useful background information regarding the likely duration of hyperglycemia in cases where a new diagnosis of T2DM was detected, and the degree of long-term pre-ED visit glycemic control for patients with a previously established T2DM diagnosis. As illustrated in case 1, Hemoglobin A1c may be useful in assessing long-term prior glycemic control when there were confounding variables present, such as an active infection, at the time of an ED visit (**Table 3**). This patient was reluctant to acknowledge a diagnosis of T2DM and to consider starting insulin shots. The A1C measured equated to an eAG of ~300 mg/dl over the preceding 2–3 months, consistent with a diagnosis of decompensated T2DM, rather than illness-related hyperglycemia or pre-DM exacerbated by infection. This information was instrumental in convincing the patient that he did have T2DM and needed to start taking insulin. Short-term improvement in glucose as documented by finger stick BG results and confirmed

Table 3.
CASE STUDIES: Potential Utility of ED POC A1C Testing

Case 1: Illness-related hyperglycemia or unrecognized T2DM diabetes?	
A 49-year-old African-American male presents to the ED with a complaint of 5–7 days of progressively worsening jaw pain. He has no known personal or family history of diabetes. He denies blurred vision, polydipsia, or polyuria. On examination, induration, erythema, and tenderness related to a right-lower molar tooth and consistent with a jaw abscess are found.	
Test results:	Plasma glucose is 415 mg/dl; creatinine is 1.1 mg/dl.
Decision point:	Is hyperglycemia secondary to infection or to previously unrecognized T2DM?
POC A1C-NOW+ test result:	11.6%. Confirms diagnosis of previously unrecognized T2DM.
Treatment:	Basal insulin and metformin therapy were initiated per the STEP-DC algorithm. The abscess was drained and antibiotic therapy was prescribed.
Follow up:	At the 2-week follow-up visit the infection is resolved. The 14-day fingerstick BG average is 150 mg/dl and the POC A1C level is 10.1%.
Case 2: Basal insulin or oral agent therapy for ED discharge?	
A 47-year-old African-American male presents to the ED with complaints of fatigue, weight loss, polyuria, and polydipsia of several weeks duration. He admits to drinking large amounts of regular soda and juice because of his thirst. He has no history of diabetes. Both of his parents and one brother have T2DM. Examination reveals acanthosis nigricans of the neck and abdominal adiposity.	
Test results:	BG is 326 mg/dl. Creatinine is 0.9 mg/dl.
Decision point:	While the protocol medication algorithm prescribed basal insulin for BG >300 mg/dl, the patient adamantly declined starting shots. Can he safely be discharged on oral agents alone?
POC A1C test result:	9.3% confirms diagnosis of T2DM.
Treatment:	He is advised to drink only calorie-free beverages and is discharged on metformin 500 mg twice daily and glipizide 10 mg once daily.
Follow up:	He has followed medical nutrition-therapy advice and taken his antihyperglycemic medications as prescribed. At 2 weeks, the fasting BG is down to 79 mg/dl and the POC A1C is 7.9%. The glipizide dose is reduced to 5 mg daily to prevent hypoglycemia.

by A1C testing at 2 weeks following initiation of lifestyle and medication management provided motivation for the patient to continue the oral agent plus basal insulin regimen prescribed, as it had proven to be both safe (no hypoglycemic episodes) and effective (improved BG control).

Point-of-care A1C at baseline was helpful in informing both patient and provider as to the likelihood that lifestyle and pharmacotherapy without insulin could be safely initiated prior to ED discharge. The patient discussed in case 2 (**Table 3**), per algorithm, was assigned to basal insulin therapy initiation; however, during the initial study visit in the ED he declined to do so. Point-of-care A1C was 9.3%, which correlates with an eAG of 220 mg/dl. Given this result and the history of ingestion of high-carbohydrate beverages, the study team decided that it would be reasonable to start the patient on oral agents first and evaluate their effectiveness in reducing BG at the second study visit. This approach, coupled with the patient's willingness to make the necessary dietary changes, was shown to have been safe, as no further visits to the ED were required during the study period of 4 weeks. Point-of-care A1C change also helped to establish early efficacy of the intervention.

Hemoglobin A1c measurement does not require fasting and is considered to be unaffected by transient hyperglycemia from acute stress or illness.[12] Hemoglobin A1c testing performed by a laboratory at the time of an ED visit does not allow timely provision of results that can be incorporated into clinical decision making during the ED stay. Bayer A1C-Now+ test results allow POC testing for A1C. A1C-NOW+ results have been found to correlate well with laboratory A1C.[13] The device is certified by the National Glycohemoglobin Standardization Program, Clinical Laboratory Improvement Amendments (CLIA) waived, uses a small (5μl) blood sample, and provides results in 5 minutes.[13]

Our study provides preliminary data suggesting that POC A1C testing performed in the ED can help to inform education needs, the likely category of glucose tolerance and early impact of an ED intervention to manage uncontrolled hyperglycemia in T2DM. Hemoglobin A1c reflects a weighted average of the BG over the previous 2–3 months. When reviewed in conjunction with baseline BG, POC A1C performed in the ED provided historical information that gave some insight into whether the hyper-glycemia was a recent occurrence or was longstanding.

We found the POC A1C results to be potentially useful in several ways. For example, a BG level in the low 400s mg/dl with A1C of almost 12% in case 1 clearly confirmed established, uncontrolled DM and a need for initiation of insulin treatment. While our medication algorithm did not incorporate A1C in the decision regarding selection of the DM regimen, it is possible that the same BG coupled with a considerably lower A1C would be consistent with a shorter duration of marked hyperglycemia, e.g., precipitated by dietary indiscretion or an intercurrent illness, affording the possibility that an oral agent might be a reasonable therapeutic option. This was particularly true if a remediable lifestyle factor, e.g., ingesting high volumes of regular soda, or a comorbid medical condition such as active infection, played a role in the hyperglycemia that precipitated the ED visit.

Because of the high proportion of patients who had A1C levels >13%, which is the upper limit for the A1CNow+ test, the change in mean A1C over the first 2 weeks of the study, while statistically significant, likely underestimated the magnitude of improvement in glycemic control that had taken place. We were able to observe clinically meaningful drops in A1C (maximum of 3.5% in 2 weeks), which (a) encouraged patient adherence by providing what we believe to be concrete evidence of successful self-management and (b) allowed the practitioner to evaluate the overall short-term efficacy of the intervention. If a POC A1C in the ED is >13%, a clinical laboratory A1C would be required to quantitate the level accurately.

Finally, POC A1C testing in the ED could also potentially be used in patients where the diagnosis of DM is equivocal, yet clearly higher than 6.5% as, this cut point is now accepted as a diagnostic criterion for DM. In our study, BG >200 mg/dl was an inclusion criteria. As eAG in this range correlates with A1C in the 8–9% range, we cannot comment further on potential correlates of A1C with lesser degrees of hyperglycemia in the ED setting.

Additional research is needed to further define the potential for A1C POC testing in the evaluation and management of patients presenting to the ED with hyperglycemia.

Limitations

Our study sample size was small, an inherent feature of our pilot study design. We did not quantitate POC A1C-NOW+ results that were >13%, so we are unable to fully assess the impact of our intervention on short-term change in A1C results.

There are conditions that necessitate use of either a specific A1C assay method or that will preclude A1C testing completely, for example, hemoglobinopathies, such as HbS, HbC, HbF, and HbE. Some assay methods correct for the presence of the most common of these traits or are unaffected by them. Increased red blood cell turnover in conditions such as hemolytic anemia, blood transfusions, or major blood loss will lead to unreliable results. Hemoglobin A1c levels also increase with age; however, age-specific values have not been defined.[3]

Conclusion

Use of POC A1C testing in the ED provided information that helped to clarify the presence of previously unrecognized T2DM and/or the degree of glycemic control in the 2–3 months preceding the acute care encounter in patients with known T2DM. Hemoglobin A1c also supported the case for providing timely DSME, emphasizing the role of glycemic control in the prevention of both acute and chronic complications. We observed clinically significant drops in A1C over a 2-week period. This testing encouraged patient adherence by providing evidence of successful self-management and allowed the health-care provider to evaluate the efficacy of the short-term intervention.

There appears to be potential utility for POC A1C testing incorporated into an ED setting, in conjunction with medical management and education for uncontrolled T2DM. Testing may allow clarification of the presence of previously unrecognized diabetes and make a strong case for timely implementation of steps to improve BG control, including initiation of insulin and survival-skills DSME. Research is needed to further define the potential specific role(s) of A1C POC testing in the ED.

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