Recurrent Diabetic Ketoacidosis in Inner-City Minority Patients

Behavioral, socioeconomic, and psychosocial factors

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OBJECTIVE—To conduct a bedside study to determine the factors driving insulin noncompliance in inner-city patients with recurrent diabetic ketoacidosis (DKA).

RESEARCH DESIGN AND METHODS—We analyzed socioeconomic and psychological factors in 164 adult patients with DKA who were admitted to Grady Hospital between July 2007 and August 2010, including demographics, diabetes treatment, education, and mental illness. The Patient Health Questionnaire-9 and the Short Form-36 surveys were used to screen for depression and assess quality of life.

RESULTS—The average number of admissions was 4.5 ± 7 per patient. A total of 73 patients presented with first-time DKA, and 91 presented with recurrent DKA; 96% of patients were African American. Insulin discontinuation was the leading precipitating cause in 68% of patients; other causes were new-onset diabetes (10%), infection (15%), medical illness (4%), and undetermined causes (3%). Among those who stopped insulin, 32% gave no reasons for stopping, 27% reported lack of money to buy insulin, 19% felt sick, 15% were away from their supply, and 5% were stretching insulin. Compared with first-time DKA, those with recurrent episodes had longer duration of diabetes ($P < 0.001$), were a younger age at the onset of diabetes ($P = 0.04$), and had higher rates of depression ($P = 0.04$), alcohol ($P = 0.047$) and drug ($P < 0.001$) abuse, and homelessness ($P = 0.005$). There were no differences in quality-of-life scores, major psychiatric illnesses, or employment between groups.

CONCLUSIONS—Poor adherence to insulin therapy is the leading cause of recurrent DKA in inner-city patients. Several behavioral, socioeconomic, psychosocial, and educational factors contribute to poor compliance. The recognition of such factors and the institution of culturally appropriate interventions and education programs might reduce DKA recurrence in minority populations.

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D iabetic ketoacidosis (DKA) is the most serious diabetic emergency in patients with type 1 and type 2 diabetes (1,2). DKA is the leading cause of mortality in children and young adults with type 1 diabetes, accounting for ~50% of deaths in diabetic individuals aged <24 years (3). The number of admissions with DKA in the U.S. is >130,000 per year and has shown an upward trend, with a 30% increase in the annual number of cases between 1995 and 2005 (4). Treatment of DKA uses a large number of resources, accounting for an estimated total cost of $2.4 billion annually (5). Observational studies in adult patients with diabetes list infectious complications as the most common precipitating factor for DKA (1,6,7), followed by discontinuation of or inadequate insulin therapy; trauma; medical and surgical illnesses, including pancreatitis, myocardial infarction, cerebrovascular accident, and general surgery; and drugs (8–11).

In adult patients with type 1 diabetes, poor adherence to insulin therapy is reported as the major precipitating cause of DKA. Musey et al. (12), in a study of urban African Americans with DKA in 1995, reported that 75% of cases occurred in patients with known diabetes, and, of those patients, stopping insulin therapy was the precipitating cause in 67% of cases. Among patients who stopped insulin therapy, 50% reported a lack of money or transportation to obtain insulin, 21% stopped because of a lack of appetite, 14% stopped because of behavioral or psychological reasons, and 14% stopped because they did not know how to manage diabetes on sick days. Maldonado et al. (10) also found that noncompliance was responsible for 59% of cases of DKA in an inner-city hospital in Houston, Texas, in 1998. Over a decade ago, we reported that noncompliance with insulin treatment was responsible for 49% of DKA cases among urban blacks and for many patients having multiple admissions with DKA (7). Despite the high number of cases of DKA attributed to poor compliance, studies on causes of DKA and noncompliance have only been chart reviews; no studies have involved personal interviews with patients. Accordingly, we conducted a cross-sectional study to assess cultural, socioeconomic, and psychological factors associated with poor compliance resulting in recurrent admissions for DKA in inner-city patients.

RESEARCH DESIGN AND METHODS—We performed a cross-sectional study of adult patients with DKA who were admitted to Grady Memorial Hospital in Atlanta, Georgia, between July 2007 and August 2010. Grady Memorial Hospital is a 953-bed community teaching hospital that takes care of inner-city patients in two major counties in Atlanta. The Emory University Institutional Review Board approved the study. DKA was defined as a blood glucose >250 mg/dL and two of the following three criteria: serum bicarbonate <18 mEq/L; serum β-hydroxybutyrate >3 mmol/L; and pH <7.30 (5). Subjects with DKA were identified using the hospital's admissions roster and by reviewing a daily laboratory list

of abnormal β-hydroxybutyrate values. All patients admitted with DKA were invited to participate in this study, with the exception of those who were pregnant, had persistent altered mental status, or were unable to understand and sign the consent form. Subjects were enrolled after resolution of DKA and once they were alert, were hemodynamically stable, and were willing to participate.

Patients were interviewed to collect information on demographics, duration of diabetes, medical treatment, known diabetes complications, history of receiving diabetes education, and precipitating factors, such as infection, mental illness, substance abuse, socioeconomic status, and issues with medical compliance. Patient race was collected through the hospital's electronic medical record system and was deemed important because of the socioeconomic factors that impact medication compliance that disproportionately affect racial minority patients. We reviewed medical records to collect information on admission diagnoses; past medical history, including past Grady Memorial Hospital admissions; in-patient medications; weight; laboratory values; insulin dose; length of stay; and disposition at discharge.

During the hospital stay, we used the Patient Health Questionnaire (PHQ) 9 and the Short Form (SF) 36 quality-of-life survey to assess physical functioning and psychological well-being. The PHQ is a 9-point, well-standardized clinical tool derived from the Primary Care Evaluation of Mental Disorders Patient Health Questionnaire (PRIME-MD), which can be used to assess depression as well as response to treatment (13,14). The scores can range from 0 to 30, where a score of 5–9 supports mild depression, 10–14 supports moderate depression, 15–19 supports moderately severe depression, and ≥20 supports severe depression. Previous studies have shown good agreement between PHQ diagnoses and those of independent mental-health professionals (75% sensitivity; 90% specificity). The SF-36 has eight domains that aggregate into two summary measures: a physical component and a mental component (15,16). Higher SF-36 scores, on a range of 0–100, are indicative of more favorable physical functioning and psychological well-being. Chronic disease is well known to negatively affect overall quality of life. In an eight-country study of the effect of chronic disease on quality of life, diabetes had a high impact on patient perception of general health (17); this impact was reflected in the SF-36 scores of our patients.

Statistical analysis

Nonparametric Wilcoxon tests or Kruskal-Wallis tests were used to compare continuous variables between different groups. For categorical variables, χ^2 tests or Fisher exact tests were used. All data are expressed as means ± SD. Statistical significance was defined as $P < 0.05$.

RESULTS—The clinical characteristics of the 164 subjects, as well as a comparison between patients with first-time versus recurrent DKA, are shown in Table 1. The cohort consisted of 85 (52%) male subjects, 157 (96%) African American subjects, and 6 (3.7%) Caucasian subjects. First admission with DKA was reported in 73 patients, and 91 had recurrent DKA admissions at the time of enrollment. Overall, the mean number of admissions was 4.5 ± 7 per patient, including the index case.
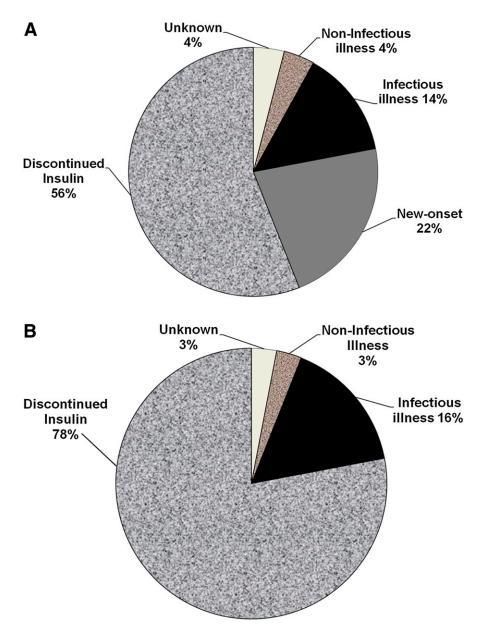
The precipitating causes of DKA are shown in Fig. 1. Newly diagnosed diabetes was reported in 16 (22%) patients with a first episode of DKA. Insulin discontinuation was the most common major precipitating cause in both patients with first-time and recurrent episodes of DKA (56 and 78%, respectively; 68% overall). If patients with new-onset diabetes are excluded from the calculation, 76% of all patients with known diabetes and 72% of those with first-time DKA and known diabetes had insulin discontinuation as their precipitating cause. The next most common cause was medical illness (18% of those with first-time DKA and 20% of those with recurrent DKA). Of the patients who discontinued insulin, 34% "just stopped," giving no clear reason for stopping, 26% lacked money to buy insulin, 17% felt too sick to take the insulin, 15% stated that their insulin supply was lost or stolen or they were away from it, and 8% were lowering their dose to stretch their supply (Fig. 2).

Table 1—Clinical characteristics at index admission

Variable	Total	First time	Recurrent	P
n	164	73	91	
Admissions prior to index	3.5 ± 6.2	0	6.4 ± 7.1	N/A
Age (years)	40.8 ± 13.3	41.2 ± 13.9	40.5 ± 12.9	0.71
BMI (kg/m^2)	27.5 ± 9.4	29.0 ± 9.7	26.4 ± 9.0	0.05
Weight (kg)	78.8 ± 26.9	87.0 ± 32.6	72.4 ± 19.4	0.004
Duration of diabetes (years)	12.2 ± 11.7	9.5 ± 11.8	14.3 ± 11.3	<0.001
Age at onset of diabetes (years)	29.7 ± 15.3	32.6 ± 15.2	27.4 ± 15.1	0.04
Length of stay (days)	4.2 ± 3.0	4.1 ± 3.0	4.3 ± 3.0	0.48
ICU admission (%)	12.2	11.0	13.2	0.81
Death [n (%)]	1 (0.61)	1 (1.4)	0 (0)	0.45
History of homelessness (%)	15.9	6.9	23.1	0.005
Employed (%)	17.2	22.2	13.2	0.13
Insured (%)	38.4	25.9	48.0	0.01
History of incarceration (%)	4.9	1.4	7.7	0.08
Married (%)	7.3	8.2	6.6	0.77
F/U in diabetes clinic (%)	49.4	27.4	67	<0.001
F/U in medical clinic (%)	42.7	37.0	47.3	0.19
Diabetes education (%)	71.6	55.9	83.9	<0.001
Know A1C (% yes)	44.8	33.3	54.4	0.01
PHQ-9 score (depression scale)	9.8 ± 7.4	10.5 ± 8.0	9.3 ± 6.8	0.53
SF-36 physical component summary (physical quality of life)	40.2 ± 7.4	40.2 ± 7.6	40.2 ± 7.2	0.75
SF-36 mental component summary (mental quality of life)	42.6 ± 8.1	42.3 ± 8.8	42.8 ± 7.6	0.67
History of depression (%)	46.3	37	53.9	0.03
Ever taken antidepressants (%)	35.8	27.8	42.2	0.06
History of bipolar or schizophrenia (%)	3.0	4.1	2.2	0.66
Alcohol abuse (%)	32.9	24.7	39.6	0.047
Illicit substance abuse (%)	38.9	22.5	51.7	<0.001
Admission blood glucose (mg/dL)	596 ± 269	592 ± 279	599 ± 261	0.66
A1C (%)	12.4 ± 2.5	12.7 ± 2.5	12.1 ± 2.4	0.21

Data are means ± SD, unless otherwise indicated. N/A, not applicable. F/U, follow-up.

A

Unknown 4%

Non-Infectious illness 4%

Infectious illness 14%

New-onset 22%

Discontinued Insulin 56%

B

Unknown 3%

Non-Infectious Illness 3%

Infectious illness 16%

Discontinued Insulin 78%

Figure 1—*Precipitating causes of DKA among 164 inner-city minority patients admitted to a community teaching hospital in Atlanta, Georgia. A: Precipitating causes in patients with a first episode of DKA. B: Precipitating causes in patients with recurrent DKA. (A high-quality color representation of this figure is available in the online issue.)*

Most patients (62%) were uninsured; 4 (3%) patients had private insurance, 17 (13%) had Medicare, and 41 (31%) had Medicaid coverage (total >100% because 10 patients had Medicaid and Medicare and 1 patient had Medicaid and private insurance). Only 28 (17%) patients had stable employment. Lack of social support was common, with 26 (16%) patients having been homeless and 8 (4.9%) having been incarcerated.

Psychiatric illnesses were prevalent in the cohort. Seventy-six (46%) patients had a history of depression, and 58 (36%) patients had a history of having ever taken antidepressants. Five (3.0%) patients carried a diagnosis of schizophrenia or bipolar disorder, and 10 (6.1%) patients had taken antipsychotic medications. The mean PHQ-9 score was 9.8 ± 7.4, which is representative of mild to moderate depression.
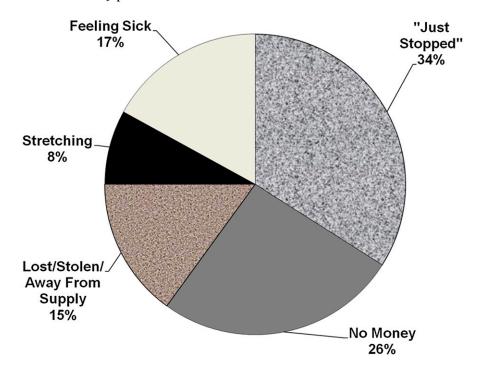
Fifty-four (33%) patients had a history of alcohol abuse, 63 (39%) patients had a history of drug abuse, and 32 (20%) patients had abused both alcohol and drugs. Significantly more patients with recurrent DKA had abused drugs compared with those with first-time DKA (52 vs. 23%; $P < 0.001$). In addition, compared

with first-time DKA, patients with recurrent DKA episodes were more likely to be homeless or have experienced homelessness. When analyzing levels of education and access to medical resources, we found that 111 (72%) patients had received diabetes education (80% of patients with known diabetes had received diabetes education), but only 65 (45%) patients knew what their A1C was.

Patient characteristics were further analyzed by the number of DKA admissions at the index admission, in categories of 0, 1–4, 5–10, and >10 admissions, as shown in Table 2. Patients with multiple episodes were leaner, had longer duration of diabetes, and developed diabetes at a younger age. Patients with multiple DKA episodes had a higher rate of having received diabetes education; however, there was no significant increase in knowledge of the meaning of A1C as the number of admissions increased. Also, with increasing number of admissions, there was a significant increase in history of homelessness, incarceration, and drug abuse, with over three-quarters of patients with ≥10 admissions having abused illicit substances.

CONCLUSIONS—This study determined clinical, socioeconomic, and psychological factors associated with the recurrence of DKA in inner-city minority patients. Our results indicate that discontinuation of insulin therapy was the major precipitating cause and accounted for over two-thirds of all DKA admissions. Several behavioral, socioeconomic, and psychosocial factors contributed to poor treatment adherence. Among patients with poor compliance with insulin therapy, one-third of patients "just stopped" (gave no clear reason for stopping insulin), one-third reported financial troubles, and most of the rest reported being away from their supply (lost, stolen, etc.) or did not know how to handle insulin on sick days. In addition, about one-half of patients with recurrent DKA who discontinued insulin had a history of alcohol or drug abuse or depression.

Insulin discontinuation has long been recognized as an important precipitating cause of DKA in retrospective studies. Observational studies in urban African Americans have reported that more than one-half of DKA cases in patients with diabetes were caused by noncompliance with insulin therapy (7,12). Likewise, a retrospective study in a multiethnic population in Texas listed noncompliance with insulin injections as their most

Figure 2—*Reported reasons for stopping insulin therapy among 113 patients with DKA. (A high-quality color representation of this figure is available in the online issue.)*

common precipitating cause of DKA (10). Our study confirms that poor compliance with insulin therapy is the leading precipitating cause among inner-city patients, accounting for 56% of patients with their first episode and 78% of patients with recurrent DKA admissions. The average number of previous DKA episodes for patients admitted to our institution was 3.54, with 18 patients having ≥10 DKA admissions (1 patient having 39 DKA admissions to Grady Memorial Hospital).

The importance of psychological factors in the incidence of DKA has been emphasized in recent studies. In a survey of 341 female patients with type 1 diabetes (11), it was reported that psychological problems complicated by eating disorders were a contributing factor in 20% of recurrent episodes of ketoacidosis in young women. More recently, it was reported that up to one-third of young women with type 1 diabetes have eating disturbances (18). In our study, all patients underwent screening for depression by patient-reported history, previous use of antidepressant agents, and with the PHQ-9 survey. A total of 46% of patients had a self-reported history of depression and 36% of patients had taken antidepressants prior to admission. The mean PHQ-9 score was 9.8 ± 7.4, which is suggestive of mild to moderate depression. Among patients with a history of being treated

with antidepressant medications, the median PHQ-9 score was 13, representing moderate depression. A history of depression was higher among patients with recurrent admission with DKA; however, there were no differences in PHQ-9 scores among those multiple episodes compared with those with a single episode of DKA. Sixty (37%) patients overall had PHQ-9 scores showing moderate to severe depression. This is slightly higher than the average of 32% of diabetic patients in controlled studies (19). Several patients also had more serious mental health disorders, with 3.0% of the cohort carrying a diagnosis of bipolar disorder or schizophrenia.

Despite a mandatory policy at our institution of providing inpatient diabetes education to all patients with DKA and the fact that 72% of patients previously received diabetes education, we found that fewer than one-half of our patients understood the meaning of A1C or knew their most recent value. In addition, many patients were unaware of sick-day management or the consequences of skipping or discontinuing insulin therapy. Many patients believed that because their insulin doses normally correspond with meals, if they are feeling too sick to eat, they do not need to take insulin. These results indicate that diabetes education and sick-day management should be reviewed periodically in all patients with

diabetes. It should include specific information on when to contact the health care provider, blood glucose and A1C goals, use of supplemental short- or rapid-acting insulin during illness, and, most importantly, the importance of never discontinuing insulin and of seeking immediate medical attention in the case of severe hyperglycemia. Because most people learn best through repetition, diabetes education should be repeated at least yearly, with review of basic concepts and additional supplemental concepts as well as checks for understanding and modifications for patients with recurrent DKA. A recent study in adolescents reported that an intensive home-based multidisciplinary intervention resulted in a significant decrease in DKA admissions over 2 years (20). In that study, a multidisciplinary diabetes team met with study patients frequently and addressed barriers to communication, access to care, and medical adherence on the family, school, and health care levels. Despite the expense of providing such an intensive intervention, the multidisciplinary intervention incurred less cost to the health care system as a result of a decreased number of DKA admissions.

Significant resources are spent on the cost of DKA hospitalizations. It is estimated that DKA episodes represent more than $1 of every $4 spent on direct medical care for adult patients with type 1 diabetes and $1 of every $2 in those patients experiencing multiple episodes (21). Based on an annual average of 135,000 hospitalizations for DKA in the U.S., with an average cost of $17,500 per patient, the annual hospital cost for patients with DKA may exceed $2.4 billion per year (5). Because most cases occur in patients with known diabetes and with previous DKA, the majority of DKA admissions could be prevented by improved access to medical care, proper education, and effective communication with a health care provider during an intercurrent illness. Our results, together with previous reports on the prevalence of poor compliance as a common precipitant of DKA (7,10,12), underscore the need for our health care delivery systems to address this problem. The high frequency of insulin discontinuation (often for economic reasons) as the precipitating cause for DKA illustrates the need for health care legislation for reimbursement for medications and universal health care.

We acknowledge several limitations in our study, including a relatively small number of patients and the fact that our

Table 2—Clinical characteristics according to prior number of DKA admissions

Variable	First admission	1–4 previous admissions	5–10 previous admissions	>10 previous admissions	P
Age (years)	41.2 ± 14	41.9 ± 13	39.2 ± 14	38.1 ± 11	0.67
Sex (% male)	49	59	39	59	0.39
Race (black/white/other)	92/6.9/1.4	98/2.0/0	100/0/0	100/0/0	0.6
BMI (kg/m^2)	29.0 ± 9.7	27.4 ± 10.6	25.0 ± 5.8	24.8 ± 6.4	0.2
Weight (kg)	87.0 ± 32.6	75.2 ± 18.9	67.5 ± 22.7	70.7 ± 15.4	0.02
Duration of diabetes (years)	9.5 ± 11.8	12.5 ± 10.5	13.5 ± 8.3	20.6 ± 14.8	<0.001
Age at diabetes onset (years)	32.6 ± 15.2	30.5 ± 15.6	25.7 ± 14.5	19.8 ± 11.5	0.02
Insured (%)	25.9	48.8	52.6	40	0.06
Employed (%)	22.2	15.7	13	5.9	0.42
F/U at diabetes clinic (%)	27.4	72.6	52.2	70.6	<0.001
F/U at medical clinic (%)	37.0	47.1	52.2	41.2	0.52
Received diabetes education (%)	55.9	86	76.2	87.5	0.001
Know A1C (%)	33.3	56.5	55	46.2	0.07
Alcohol abuse (%)	24.7	39.2	30.4	52.9	0.1
Drug abuse (%)	22.5	41.2	56.5	76.5	<0.001
History of depression (%)	37.0	51.0	52.2	64.7	0.13
Diagnosis of bipolar or schizophrenia (%)	4.1	2.2	0	0	>0.99
PHQ-9 score (depression scale)	10.5 ± 8	8.6 ± 6	11.1 ± 7	8.9 ± 8	0.44
SF-36 physical component summary (physical quality of life)	40.2 ± 8	40.1 ± 7	39.5 ± 8	41.8 ± 5	0.87
SF-36 mental component summary (mental quality of life)	42.3 ± 9	42.9 ± 7	42.8 ± 9	42.5 ± 5	0.95
Married (%)	8.2	5.9	4.4	11.8	0.83
History of homelessness (%)	6.9	23.5	26.1	17.7	0.02
History of incarceration (%)	1.4	3.9	8.7	17.7	0.03

Data are means ± SD, unless otherwise indicated. F/U, follow-up.

patient population included mostly inner-city African American patients admitted to a single medical institution; thus, the information may not be extrapolated to other ethnic groups or populations. A large prospective study including different ethnic groups with diverse social and economic backgrounds and insurance coverage, from academic and community hospitals in rural and urban populations, is certainly needed to better understand underlying socioeconomic, educational, and cultural factors that lead to the high rate of poor treatment adherence and recurrent DKA.

In conclusion, this cross-sectional observational study indicates that poor adherence to insulin therapy is the leading precipitating cause of DKA in inner-city minority patients. Lack of adherence to insulin treatment relates to a multitude of socioeconomic and psychosocial factors. Novel approaches to patient education incorporating a variety of health care beliefs and socioeconomic issues are critical to an effective prevention program. Because DKA represents an important financial burden and health care problem in inner-city populations, it would be wise to invest resources in expanding health care coverage and medication cost as well in developing strategies to increase treatment compliance and prevent DKA admissions.

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