Does Age at Diabetes Diagnosis Influence Long-Term Physical and Behavioral Outcomes?

AARON E. CARROLL, MD, MS[1,2]
RONALD T. ACKERMANN, MD, MPH[2,3,4]
EDWARD J. BRIZENDINE, MS[3]
CHANGYU SHEN, PHD[2,3]
DAVID G. MARRERO, PHD[2,3,4]

Type 1 diabetes is a complex chronic illness. Because self-care is such an essential element of successful diabetes management, cognitive and behavioral aspects of childhood development may interfere with effective self-care behaviors and impact the probability of later complications. The objective of this study was to examine whether the age at diagnosis of diabetes is significantly related to physical and behavioral outcomes in adulthood. It may be that children diagnosed in adolescence spend their first few years with diabetes rebelling against the therapeutic demands of treatment. An intense phase of inadequate care could lead to health consequences later in life; behaviors adopted in adolescence could also linger long into adulthood. Conversely, it is possible that being diagnosed very early in life leads to a dependence on others that affects health and behavior long into the future.

RESEARCH DESIGN AND METHODS — This study used the patient survey data collected as part of the Translating Research into Action for Diabetes (TRIAD) study, which has been previously described (1). All patients with diabetes who participated in the TRIAD study, had baseline patient survey and chart review data for the period between July 2000 and October 2001, and reported being diagnosed with diabetes at or before 21 years of age were selected for inclusion in this study. The CASRO response rate was 69% (2).

We extracted information about health and social outcomes. Health outcomes included reported weight, BMI, prevalences of heart attack and stroke, and self-reported general health. We also assessed physical health status using a 12-item short form with physical component subscores (3). Social outcomes included levels of income and education and smoking behavior. Demographic data were gathered for each patient, including age at time of interview, number of years since diagnosis, race, and sex. The main predictor was self-reported age at diagnosis of diabetes.

To adjust for potential confounding factors in analyses of continuous outcome variables, we used multiple regressions. Covariates included in all of the models were sex, race/ethnicity, and duration of diabetes. Even though age is a continuous variable, we divided age at diabetes onset into three categories (0–9, 10–13, and 14–21 years) in order to more adequately reflect our hypothesis and to be consistent with prior studies that performed similar analyses (4–6). For linear regression models, we estimated the β-coefficient (slope) and its 95% CI for the age at diabetes onset. For logistic regression models, we estimated the odds ratio (OR) and its 95% CI for the age at diabetes onset. Statistical significance was defined at 0.05 (two sided).

RESULTS — A total of 590 participants met inclusion criteria for this study. Over one-half of participants were female (59.8%), and 43.4% were nonwhite. Almost one-half (48.6%) were diagnosed with diabetes at 14–21 years of age, with the remainder diagnosed between 0–9 years of age (29.5%) and 10–13 years of age (21.9%). Mean current age at the time of the TRIAD study did not differ significantly across the three diabetes age-at-onset categories. Because of this, mean duration of diabetes was the longest for individuals diagnosed between 0 and 9 years of age (duration 32.7 years) and the shortest for those diagnosed between 14 and 21 years of age (duration 24.6 years). There were no differences in reported treatment by patient and age at diagnosis group.

Adjusted associations between age at onset and later health outcomes

After adjusting for personal characteristics and duration of disease, individuals diagnosed between 14 and 21 years of age were significantly heavier (BMI 1.99 kg/m^2 [95% CI 0.46–3.52]) than those diagnosed between 10 and 13 years of age. Those diagnosed between 0 and 9 years of age were significantly less likely to have had a heart attack (OR 0.48 [95% CI 0.23–0.97]) than those diagnosed between 10 and 13 years of age. In adjusted models, there were no statistically significant associations between age at onset and stroke or quality of life. Interestingly, patients diagnosed between 14 and 21 years of age were significantly less likely to have smoked in the last year (0.45 [0.27–0.74]) than those diagnosed between 10 and 13 years of age (Table 1). Those diagnosed between 0 and 9 years of age may have had this same relationship, but it was not statistically significant (0.73 [0.42–1.25]). Although the relationships between the age at diagnosis and other social outcomes (i.e., household income and education attainment) trended toward the results seen in the unadjusted data, none were statistically significant.

From the [1]Department of Children's Health Services Research, Indiana University, Indianapolis, Indiana; the [2]Regenstrief Institute for Health Care, Indianapolis, Indiana; the [3]Indiana University School of Medicine, Indianapolis, Indiana; and the [4]Diabetes Prevention and Control Center, Indiana University, Indianapolis, Indiana.

Address correspondence and reprint requests to Aaron E. Carroll, MD, MS, HITS (Health Information and Translational Science) Building, Room 1020, 410 W. 10th St., Indianapolis, IN 46202. E-mail: aecarro@iupui.edu.

Received for publication 21 March 2007 and accepted in revised form 27 July 2007.

Published ahead of print at http://care.diabetesjournals.org on 6 August 2007. DOI: 10.2337/dc07-0563.

Abbreviations: TRIAD, Translating Research into Action for Diabetes.

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

Table 1—*Adjusted associations between age at diagnosis and current social and behavioral outcomes**

	Age at onset*	
	0–9 years old	14–21 years old
Education (high school or more)	0.91 (0.44–1.89)	0.86 (0.42–1.74)
Annual income over $40k	0.83 (0.50–1.38)	1.02 (0.64–1.64)
Smoked cigarettes in last year	0.73 (0.42–1.25)	0.45 (0.27–0.74)

Data are OR (95% CI). *All results are comparisons with adolescent age at onset (10–13 years old). Adjusted ORs include 95% CI, as determined using logistic regression models. All models adjusted for sex, race, and duration of diabetes in years.

CONCLUSIONS— Our analyses show that the timing of childhood diabetes diagnosis is significantly associated with important health-related factors later in life. After adjusting for duration of disease, children diagnosed between 10 and 13 years of age were significantly more likely to have had a heart attack than those diagnosed between 0 and 9 years of age. We also found that children diagnosed between 10 and 13 years of age were more likely to have adopted a risky behavior (e.g., smoking that continues in adulthood) than those diagnosed between 14 and 21 years of age.

There are several limitations to this study. Our sample size was relatively small and may have lacked statistical power to detect meaningful differences in some of the main outcome variables. Our study was also cross-sectional and included analyses of several outcomes that depended on recall of events. In addition, although participants across the three study groups were diagnosed with diabetes as either children or adolescents, an average of ∼30 years ago, it is possible that some had type 2 diabetes. This seems unlikely, however, given that a diagnosis of type 2 diabetes was extremely rare during the era in which the diagnosis was made. We made every effort to identify those who might have type 2 diabetes and conducted sensitivity analyses. Our analysis was also limited by the fact that it is impossible to control for both diabetes duration and current age in a regression setting, due to the dependencies among age at onset, diabetes duration, and current age.

Diabetes is a difficult disease to manage under ideal conditions. The unique demands of adolescent development, particularly the separation from parental norms and the development of a self-identity, clearly can impact the demands of diabetes treatment. Our data suggest that age at diagnosis may be an important factor in long-term outcomes associated with the disease.

Acknowledgments— This research was funded by grants from the National Institutes of Health (1 K23 DK067879-01 to A.E.C.) and by Program Announcement no. 04005 from the Centers for Disease Control and Prevention (Division of Diabetes Translation) and the National Institute of Diabetes and Digestive and Kidney Diseases as part of the TRIAD study.

References

1. The Translating Research Into Action for Diabetes (TRIAD) study: a multicenter study of diabetes in managed care. *Diabetes Care* 25:386–389, 2002
2. Frankel L: The report of the CASRO Task Force on response rates. In *Improving Data Quality In a Sample Survey*. Wiseman R, Ed. Cambridge, MA, Marketing Science Institute, 1983, p. 1–11
3. Ware J Jr, Kosinski M, Keller SD: A 12-item short-form health survey: construction of scales and preliminary tests of reliability and validity. *Med Care* 34:220–233, 1996
4. Kaufman FR, Epport K, Engilman R, Halvorson M: Neurocognitive functioning in children diagnosed with diabetes before age 10 years. *J Diabetes Complications* 13: 31–38, 1999
5. Krolewski AS, Warram JH, Rand LI, Christlieb AR, Busick EJ, Kahn CR: Risk of proliferative diabetic retinopathy in juvenile-onset type 1 diabetes: a 40-yr follow-up study. *Diabetes Care* 9:443–452, 1986
6. Ryan CM, Morrow LA: Self-esteem in diabetic adolescents: relationship between age at onset and gender. *J Consult Clin Psychol* 54:730–731, 1986