

# Effectiveness of a Prevention Program for Diabetic Ketoacidosis in Children

## An 8-year study in schools and private practices

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**OBJECTIVE** — To shorten the period of carbohydrate intolerance preceding the diagnosis of IDDM in children.

**RESEARCH DESIGN AND METHODS** — The incidence of diabetic ketoacidosis (DKA) was studied in newly diagnosed diabetic children aged 6–14 years, in the area of Parma, Italy, 8 years after an information program on DKA was introduced to teachers, students, parents, and pediatricians. Information was provided by displaying a poster with a few practical messages in 177 primary and secondary public schools. The pediatricians working in the same area were given equipment for the measurement of both glycosuria and blood glucose levels, as well as cards listing guidelines for the early diagnosis of diabetes, to be given to patients. A toll-free number was also provided. Clinical and laboratory features of 24 young diabetic patients diagnosed in the Parma area (group 1) were compared with those of 30 patients coming from two nearby areas in which no campaign for the prevention of DKA had been carried out (group 2).

**RESULTS** — From 1 January 1991 to 31 December 1997, DKA was diagnosed in 3 children from group 1 (12.5%) and in 25 children from group 2 (83.0%) ( $\chi^2 = 26.8$ ;  $P = 0.0001$ ). The three cases of DKA in group 1 were observed in 1991 ( $n = 1$ ) and in 1992 ( $n = 2$ ). No patients from the Parma area who had DKA were admitted to our unit after 1992. The duration of symptoms before diagnosis was  $5.0 \pm 6.0$  and  $28.0 \pm 10.0$  days ( $P < 0.0001$ ), in groups 1 and 2, respectively. Metabolic derangements were less severe in patients of group 1 than in those of group 2. Hospitalization for the treatment of overt diabetes and for the teaching of self-management of the disease lasted  $5.4 \pm 1.2$  days in group 1 and  $13.3 \pm 2.4$  days in group 2 ( $P = 0.002$ ). The total cost of the 8-year campaign was \$23,470.

**CONCLUSIONS** — The prevention program for DKA in diabetic children aged 6–14 years, carried out in the Parma area during the last 8 years, was successful. Thanks to this program, cumulative frequency of DKA in new-onset IDDM decreased from 78% during 1987–1991 to 12.5% during 1991–1997. None of the newly diagnosed diabetic children aged 6–14 years and from the Parma area were ever admitted to the hospital for DKA after 1992.

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**D**iabetic ketoacidosis (DKA) is a complication of new-onset IDDM and may be defined as a metabolic derangement characterized by the triad hyperglycemia ( $>250$  mg/dl), acidosis (arterial pH  $<7.3$  and/or bicarbonate  $<15$  mEq/l), and ketonuria (1,2). DKA is reported in ~20–40% of newly diagnosed diabetic patients (3), and when unrecognized, it may lead to impairment of con-

sciousness and even death (4). Our hypothesis was that DKA could be prevented by shortening the period of carbohydrate intolerance that usually precedes the diagnosis of IDDM.

To test this hypothesis, we decided in 1991 to promote a campaign for DKA prevention in our area, where  $25.4 \pm 3.2$  days are necessary for the diagnosis of IDDM and DKA occurs in 78% of newly diagnosed diabetic patients. The campaign aimed 1) to provide medical information on DKA to teachers, students, and parents in schools and in the private practice offices of general pediatricians in the Italian province of Parma and 2) to give the opportunity to the pediatricians working in the same area to measure blood glucose levels and check for the presence of glycosuria. The results of this campaign were analyzed 8 years later.

**RESEARCH DESIGN AND METHODS** — Information was provided by displaying a brightly colored poster ( $100 \times 80$  cm) showing a child sleeping as well as some practical messages for parents and teachers. The messages were as follows: "Does your child... drink and urinate more than usual? Has he started wetting the bed again?... Make sure he does not have high blood sugar levels... Call your paediatrician today... Children too can have diabetes." The picture of a child sleeping was chosen to focus on the occurrence of nocturnal enuresis in a usually "dry" child. In our personal experience, in fact, the first symptom of diabetes reported by 89% of parents is unusual bed-wetting (5).

One thousand posters were displayed in 177 primary and secondary public schools of the Italian province of Parma. During the 8-year study, these schools were attended by a total of 144,736 children aged 6–14 years, corresponding to 18,092 children per year.

The aim of this campaign was explained to teachers and students by nurses and residents who specialized in pediatrics and had experience in the diagnosis and treatment of diabetes in children and adolescents. Teachers were invited to show and explain the poster to the parents during meetings organized in the schools. At the beginning of

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**Abbreviations:** DKA, diabetic ketoacidosis.

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

**Table 1— Clinical and laboratory abnormalities of two groups of patients at presentation**

	Origin of patients	
	Province of Parma (group 1)	Elsewhere (group 2)
Frequency of symptoms (%)		
Bed-wetting (noticed by parents)	88.8*	37.0
Polyuria	91.0	90.2
Polydipsia	94.1	92.0
Recent weight loss (>10%)	32.6*	89.7
Duration of symptoms (days)		
Mean	5.0 ± 6.0*	28.0 ± 10.0
Maximum	10	62
Clinical signs and laboratory mean values		
Impaired level of consciousness (%)	0	10
Blood glucose (mg/dl)	424 ± 84†	654 ± 98
Blood pH	7.35 ± 0.05†	7.29 ± 0.04
Serum bicarbonate (mEq/l)	18.5 ± 0.02†	11.6 ± 3.2
HbA <sub>1c</sub> (%)	9.4 ± 1.1†	14.5 ± 2.6
C peptide (pmol/ml)	0.15 ± 0.06	0.12 ± 0.02

Data are means ± SD unless otherwise indicated. \* $P < 0.0001$ ; † $P < 0.001$ .

each school year, a committee formed by members of the Parents' Association for Diabetic Children and Adolescents of Parma verified whether the posters were displayed.

Sixty additional posters were issued to 52 pediatricians working in the same area and were displayed in their private offices. In addition, 104 cards with guidelines for the diagnosis of diabetes were also distributed. On the front of the card, early symptoms (bed-wetting, nycturia, and thirst) and late symptoms (polyuria, polydipsia, weight loss, and fatigue) of incipient diabetes were listed, and on the reverse side, the criteria for the diagnosis of IDDM according to the World Health Organization (6) were reported. In a final statement, pediatricians were asked to promptly refer children with the above-mentioned clinical features to the diabetes unit of the department of pediatrics at the University of Parma. To facilitate contact with our diabetes unit, a toll-free number was provided to teachers, parents, and pediatricians.

Each pediatrician was also equipped with devices for the measurement of capillary blood glucose and glycosuria, supplies for finger pricking, reagent strips, and a reflectance meter (OneTouch; LifeScan, Milpitas, CA). Two 1-h meetings were organized to instruct pediatricians in the measurement of capillary blood glucose and to give them more information on the criteria for early diagnosis of IDDM and on the warning signs of the disease. These meetings were held by nurses and pediatricians from our unit who were experienced in the management of diabetes.

Clinical and laboratory features of children 6–14 years old whose diabetes was diagnosed in the province of Parma were compared with those of peers from the two nearby provinces of Piacenza and Reggio Emilia, where no campaign for the prevention of DKA was carried out. Parma, Piacenza, and Reggio Emilia are all provinces of Emilia Romagna and thus are similar in environment, health service, socioeconomic status of the inhabitants, and number of students <14 years of age. The total number of children 6–14 years of age who were involved in the study was 438,232. The annual incidence of IDDM in this region of Northern Italy is 10.5 of 100,000 children aged 6–14 years (M.V., unpublished observations), so that 45 newly diagnosed diabetic children in the total period were estimated to be recruited for the study. According to our regional health care system, all IDDM patients aged 6–14 years within the area of Piacenza, Parma, and Reggio Emilia must be referred to the diabetes unit of the department of pediatrics at the University of Parma. Thus, all newly diagnosed IDDM children 6–14 years old in the above-mentioned area were enrolled in the study.

Analysis of variance for the comparison of mean values and the  $\chi^2$  test for the comparison of percentages were used.  $P < 0.05$  was considered significant. Data are reported as means ± SD.

**RESULTS** — From 1 January 1991 to 31 December 1997, 148 children aged 45

days to 18 years with new-onset IDDM were admitted to the department of pediatrics at the University of Parma. As expected, 54 (36.4%) of them were 6–14 years old (29 boys, 25 girls; mean age ± SD: 8.9 ± 1.4 years [range 6.3–14.0]). Of these children, 24 (13 girls, 11 boys; 8.3 ± 1.8 years old) came from the province of Parma (group 1) and 30 (16 boys, 14 girls; 8.5 ± 1.3 years old) came from the provinces of Reggio Emilia and Piacenza (group 2).

DKA was present in only 3 children (12.5%) from group 1 and in 25 children (83.0%) from group 2 ( $\chi^2 = 26.8$ ;  $P = 0.0001$ ). The three cases of DKA in group 1 were observed in 1991 ( $n = 1$ ) and 1992 ( $n = 2$ ). No patients with DKA who were from the province of Parma were admitted to our unit after 1992. On the contrary, the cases of DKA in group 2 were homogeneously distributed within the period 1991–1997. Clinical and laboratory abnormalities of both groups of patients at presentation are summarized in Table 1. Duration of symptoms before diagnosis was 5.0 ± 6.0 and 28.0 ± 10.0 days ( $P < 0.0001$ ) in groups 1 and 2, respectively. Impaired level of consciousness was found in only three patients of group 2. Hospitalization for the treatment of overt diabetes and the teaching of self-management of the disease lasted 5.4 ± 1.2 days in group 1 and 13.3 ± 2.4 days in group 2 ( $P = 0.002$ ).

During the study, 2,072 blood glucose levels and 641 urine glucose levels were measured by pediatricians from the province of Parma. In the same period, 4,031 calls were made to our diabetes unit by parents (49%), teachers (21%), adolescents (15%), and pediatricians (15%), all of whom were asking for more information, particularly on symptoms such as enuresis and nycturia.

Of the parents of the patients in group 1, 57% acknowledged that the messages displayed in the poster prompted them to consult a pediatrician. The same messages led a teacher to the timely detection of the initial phase of diabetes in three patients. In 69% of the cases, pediatricians were able to refer the symptoms reported by the families to latent hyperglycemia. None of the parents of patients in group 2 knew that bed-wetting in a child who is usually "dry" might be associated with IDDM. Nine patients of this group, however, sought medical attention because of nocturnal enuresis, but the pediatrician failed to recognize the symptom as secondary to hyperglycemia.

The total cost of the 8-year campaign was \$23,470 and included the costs for the toll-free telephone line (27%), the posters (26.2%), and the time spent by nurses and residents to answer the phone (34.8%) and to educate the teachers, parents, and pediatricians (12%). The cost to the national health care system for the treatment and education of inpatients was \$196,457 and \$53,356 for children with and without DKA, respectively.

**CONCLUSIONS** — The program for prevention of DKA in newly diagnosed diabetic children carried out in the province of Parma in the last 8 years was effective. In fact, thanks to this program, the cumulative frequency of DKA in new-onset IDDM in this area decreased from 78% in the 1987–1991 period to 12.5% in the 1991–1997 period. The goal reached is even more impressive when one considers that none of the newly diagnosed diabetic children who were 6–14 years old and were from the same province were ever admitted to the diabetes unit with DKA after 1992. This result is to be ascribed to the prevention program because in the two provinces where the program was not carried out, the incidence of IDDM with DKA was higher and similar to the one observed in the province of Parma before 1991.

The decreased incidence of DKA may also be attributed to the shorter period of metabolic derangement preceding the appearance of overt diabetes in the patients from the province of Parma compared with those from the other areas. This shorter period led to less severe laboratory abnormalities at diagnosis and, therefore, to reduction in both the occurrence of impairment of consciousness and the duration of hospitalization.

Prevention of DKA is crucial for the prognosis of diabetes. Despite the improvements in insulin therapy and disease monitoring, mortality from the disease has not improved, and has remained the same as that reported in the 1970s, i.e., 1–2% of newly diagnosed diabetic children (1,7). Most deaths in these patients are due to metabolic derangement secondary to DKA and its complications (4,8).

We observed that the most important warning symptoms for the early diagnosis of IDDM in children are enuresis and nycturia (3). Many parents reported that unusual bed-wetting in a previously “dry” child occurred long before the diagnosis of IDDM; however, only in a few cases (13.1%) were these parents able to suspect the presence of hyperglycemia (5). Our prevention program was specifically aimed at detection of this early symptom. The messages displayed on the poster were positively perceived, as demonstrated by the great number of calls received by our toll-free number and by consultations, as well as by the number of capillary blood glucose determinations performed by the pediatricians. Consequently, pediatricians were able to attribute the symptoms reported by families and teachers to the presence of latent hyperglycemia in a percentage of cases five-fold greater than that observed in the same area before the prevention program was given (5).

In conclusion, the results of the present study demonstrate that by means of an aggressive and relatively inexpensive campaign of information on the early symptoms of diabetes, it is possible to reduce the incidence of DKA in children with new-onset diabetes.

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