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Hypoglycemia in Children and Adolescents with Type 1 Diabetes in the Pediatric Department of Abass Hospital Ndao (Dakar)

Djibril Boiro[1*], Aliou A. Ndongo[1], Amadou Sow[1], Aminata Mbaye[2], Ndèye Fatou Fall[1], Ndiogou Seck[3], Ndeye Fatou Sow[4], Babacar Niang[2], Younoussa Keïta[1], Modou Guéye[1]

[1]Abass Ndao Hospital Center, Dakar, Senegal
[2]Albert Royer Children's Hospital, Dakar, Senegal
[3]Regional Hospital Center of St Louis, Saint Louis, Senegal
[4]Dalal Diam Hospital, Dakar, Senegal
Email: *djibrilboiro@yahoo.fr, *djibril.boiro@ucad.edu.sn

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Abstract

Hypoglycemia in diabetics is defined by the ADA as a blood glucose level below 3.9 mmol /L (<70 mg/dl) associated or not with typical symptoms and improvement of symptoms when taking glucose. The objective of our study was to determine the factors associated with hypoglycemia in our diabetic patients. **Methodology:** Abass Hospital Ndao over 3 months (from March 2023 to May 2023). All patients who had hypoglycemia in the 30 days preceding data collection and who met our inclusion criteria were selected. **Results:** Our study included 38 cases, representing a prevalence of 34% compared to diabetology consultations and a prevalence of severe hypoglycemia of 18%. The mean age of our patients was 13 years. The sex ratio was 1.2. There was no significant link between sex and the number of hypoglycemias. The duration of diabetes was less than 5 years in the majority of cases and was positively correlated with hypoglycemic episodes. The socioeconomic level of the patients was low in the majority of cases. Human or regular insulin was used in 82%. The 3-injection regimen was used in 92% of cases. The mean insulin dose was 0.77 IU/kg/d [0.08 - 1.3 IU/kg/d]. A significant link between the number of hypoglycemic episodes and the type of insulin as well as the insulin doses was not established. However, human insulin was associated with a higher risk of hypoglycemia. Football was the most practiced sport (52% of cases). In our study, 21% of patients had a target glycated hemoglobin level (less than or equal to 7.5%) and 15.8% a level greater than 13%. There was no significant link between hypoglycemic episodes and the drop in glycated hemoglobin between 2 trimesters. The circumstances of occurrence were sport and delayed

meal intake each in 25% of patients. We noted insufficient meal intake in 30% of patients, insulin overdose in 10% of cases and an injection without meal intake in 4% of cases. **Conclusion:** Hypoglycemia is common in children and adolescents with type 1 diabetes on insulin therapy. Severe forms are uncommon. Young age is correlated with a higher risk of hypoglycemia. Despite high hemoglobin levels, the risk of hypoglycemia remains.

Keywords

Hypoglycemia, Type 1 Diabetes, Insulin, Abass Ndao

1. Introduction

Hypoglycemia in diabetics is defined by a blood glucose level below 3.9 mmol /L (<70 mg/dl) associated or not with typical symptoms and improvement of symptoms when taking glucose [1]. It results from an imbalance between insulin dose, diet and physical activity [2].

Younger children are at higher risk for severe hypoglycemia [3]. Traditional approaches to hypoglycemia prevention, including patient education about modifiable risk factors for hypoglycemia (changes in insulin, diet, and exercise) and frequency of blood glucose monitoring remain important for hypoglycemia prevention [4]. Severe hypoglycemia with cognitive impairment, such as a convulsion and coma, is a lethal condition and is associated with later-onset cognitive impairment and brain-structural abnormalities, especially in young children. Therefore, reducing the frequency of hypoglycemia and minimizing the occurrence of severe hypoglycemia are critical issues in the management of children and adolescents with type 1 diabetes. Advanced diabetes technologies, including continuous glucose monitoring and sensor-augmented insulin pumps with low-glucose suspension systems, can reduce the frequency of hypoglycemia and the occurrence of severe hypoglycemia without aggravating glycemic control [5].

In Senegal, there is no study specifically on this subject. In this context, we wondered whether there might be other factors contributing to the occurrence of hypoglycaemia. The main objective of which was to determine the factors associated with hypoglycemia in our diabetic patients.

2. Methodology

This was a descriptive and analytical cross-sectional study. The study was conducted over a period of 3 months (March 2023 to May 2023).

It took place at the Abass Hospital Center Ndao in the Dakar region. It is a level III health facility.

2.1. Inclusion Criteria

- Diabetic patients aged less than or equal to 18 years are monitored in the de-

partment.

- Patients with a blood sugar monitoring notebook
- Patients who have had at least one episode of hypoglycemia in the last 30 days preceding the collection of information.

2.2. Non-Inclusion Criteria

- Patients with a monitoring notebook that was incorrectly or not completed or was not available at the time of collection.
- Patients refusing to submit to the questionnaire.

Patients were approached at their follow-up appointment. Data were collected using a pre-established survey form by questioning the patient or their guardian after consent.

2.3. Sampling

All outpatients with hypoglycaemia in the last 30 days who met the inclusion criteria constituted our study population.

2.4. Data Collection Procedure

Patients were interviewed during their follow-up appointments. Data were collected using a pre-established survey form. The data was collected using a data collection form for all patients, completed by questioning the patients or their guardians.

2.5. Operational Definition of Variables

- The glycated hemoglobin level measured in the department with the EKF Diagnostics device named "Quo-Lab" during the last 2 quarters was reported. Arbitrarily, It was classified according to the objectives described (<7.5%,] 7.5 - 9%],]9 - 13%], > 13);
- Therapeutic education on hypoglycemia was assessed on the basis of recognition of clinical signs of hypoglycemia, threshold value, means of resugar, and glycemic control after correction (extract from patient education sheet for the Changing Program Diabetes in Children used in the service).
- The hypoglycemia episodes were classified into 2 groups: those with a maximum of 5 (tolerated threshold, *i.e.*, 5% of the blood sugar levels taken, *i.e.*, 90 blood sugar levels taken on average) and those greater than 5. Hypoglycemia was classified as severe if there were associated neurological signs.
- The circumstances of the diagnosis of hypoglycemic episodes were defined: in front of the clinical signs, the measurement of capillary blood glucose (threshold fixed < 70 mg/dl) or both.

2.6. Data Management

All data were collected and stored on a computer. Excel 2010 software was used for data collection and descriptive analysis.

For the bivariate analysis, we performed a Chi-square independence test using R software. The test was significant if the p-value is ≤ 0.05. The odds ratio was used to assess the risk of hypoglycemia.

3. Results

During our study period, 110 patients consulted for T1D and 38 patients had experienced hypoglycemia in the previous 30 days, a prevalence of 34.5%. The prevalence of severe hypoglycemia was 18%.

The mean age of our patients was 13 years with a standard deviation of ± 4 years. The median was 15 years. Fifty percent of our patients were older than 15 years.

Males accounted for 55% of cases with a sex ratio of 1.2. The socio-economic level was low in 60.53% of cases, average in 36.84%.

The duration of diabetes development was less than 1 year in 37% of cases. The minimum duration of development was 4 months and the maximum was 14 years with an average of 10 years ± 4 years.

The mean age of discovery was 10 years with a standard deviation of ± 4 years.

Human insulin was used in 82% of cases. The 3-injection regimen was used in 92% of cases. The mean insulin dose was 0.77 IU/kg/day ± 0.23 IU/kg/day and a median of 0.8 IU/kg/day. Twenty-six percent of our patients followed a special diet. Twenty-five of our patients practiced physical activity, *i.e.*, 66% of cases. The minimum duration per week was 1 hour and the maximum was 14 hours.

Twenty-one percent of patients had an HbA1c level less than or equal to 7.5% (Figure 1).

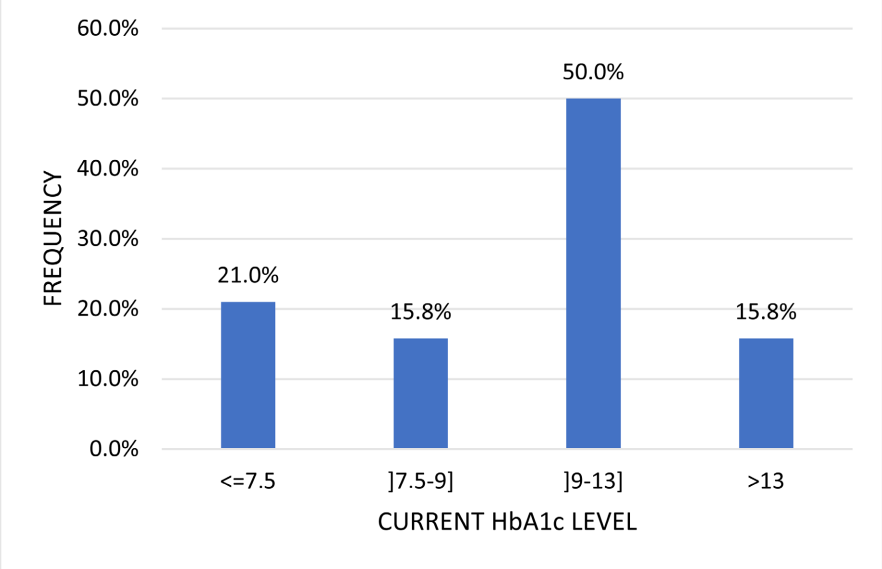

Figure 1. Distribution of patients according to HbA1c level.

Overall, the current glycated hemoglobin curve is below that of hemoglobin 3 months before. At times, there is a superposition of the 2 curves (Figure 2).

We noted that 26 patients and/or their parents, or 68%, had a fear of hypoglycemia. We recorded a history of hospitalization for severe hypoglycemia in 7 patients or 18% of cases of hypoglycemia.

The minimum number was one episode and the maximum was 36 episodes of hypoglycemia. The average was 6. Patients who had at most 5 episodes of hypoglycemia represented 63%. The diagnosis was made by clinical signs and capillary blood glucose measurement in 84% of cases. Among the clinical signs, sweating, dizziness and tremors were reported in 47%, 47% and 37% of cases respectively (Table 1).

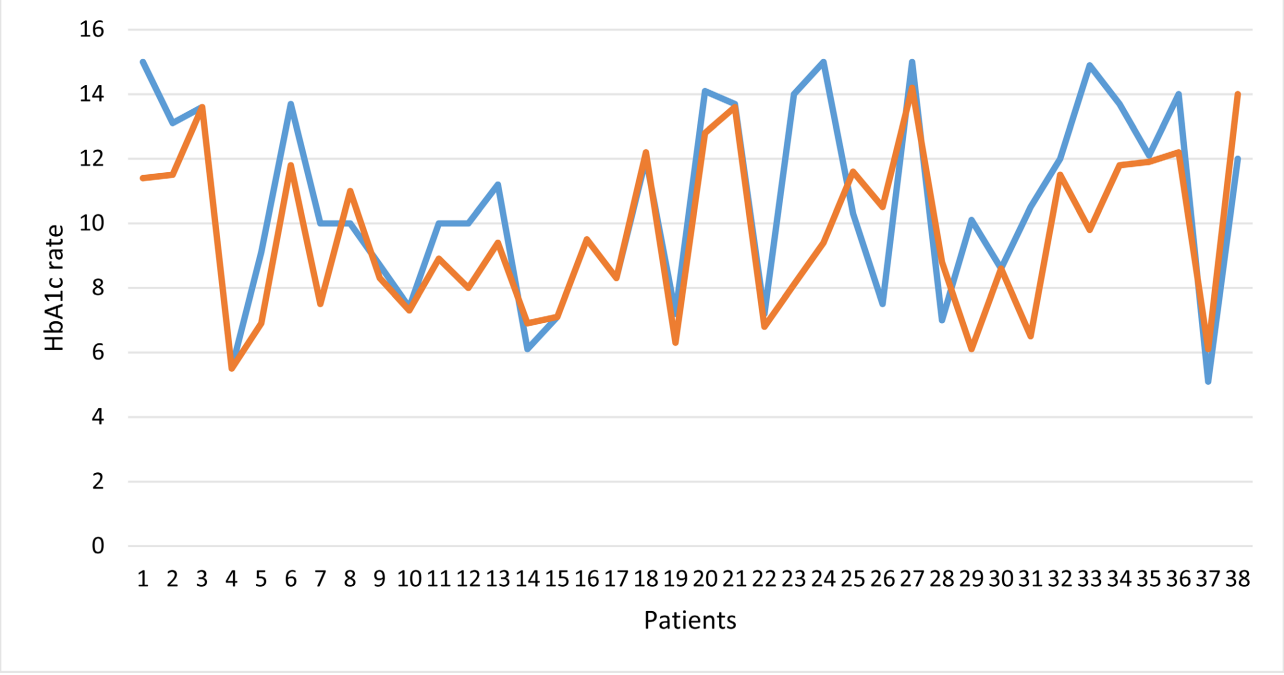

Figure 2. HbA1c rate evolution curves between 2 quarters (Blue curve: HbA1c level 3 months ago, Orange curve: current HbA1 level).

Table 1. Distribution of clinical signs of hypoglycemia.

Clinical Signs	Workforce (N = 38)	Percentage
Sweat	18	47%
Dizziness	18	47%
Tremors	14	37%
Hunger	13	34%
Headaches	10	26%
Fatigue	8	21%
Muscle weakness	6	16%
Disturbances of consciousness	7	18%
Visual blur	3	8%
Tears	2	5%
Dyskinesia of the tongue	1	3%

Among the circumstances of occurrence of hypoglycemia, sport was found in 31.5% of patients (Table 2).

The number of hypoglycemia episodes greater than 5 was associated with young age. The odds ratio was 4.17 and the p-value was equal to 0.02. The prevalence of high hypoglycemia episodes was higher in males (odds ratio = 1.8) without significant association. There was no significant association between the occurrence of hypoglycemia episodes and socioeconomic level (Table 3).

Table 2. Distribution of patients according to the circumstances of occurrence of hypoglycemia.

Circumstances of occurrence	Number of employees (N = 38)	Percentage
Sport	12	31.5%
Delayed meal	12	31.5%
Insufficient meal	14	37%
Injection without meal	2	5%
Insulin overdose	5	13%
Hypoglycemic products	3	8%

Table 3. Factors associated with the frequency of hypoglycemia.

		>5 Episodes	≤5 Episodes	P-value
Age	≤15 YEARS	10 (53%)	9 (47%)	0.02
	>15 YEARS	4 (21%)	15 (79%)	
Sex	Male	9 (43%)	12 (57%)	0.9
	Female	5 (29%)	12 (71%)	
Socio-economic level	Down	9 (39%)	14 (61%)	0.5
	AVERAGE	5 (36%)	9 (64%)	
	Pupil	0 0%	1 (100%)	
Diabetes duration	<1 year	9 (36%)	5 (64%)	0.02
	[1 - 5 years]	4 (22%)	14 (78%)	
	>5 years	1 (17%)	5 (83%)	
HbA1c	Decreased	6 (25%)	18 (75%)	0.1
	Increase	4 (50%)	4 (50%)	
	Constant	4 67%)	2 (33%)	
Insulins	Human	12 (38%)	19 (72%)	0.9
	Modern	2 (29%)	5 (71%)	
Sport	Yes	8 (32%)	17 (68%)	0.5
	No	6 (46%)	7 (54%)	

The prevalence of high hypoglycemic episodes was 36% in patients with diabetes duration less than 1 year. The p-value was 0.02.

The number of hypoglycemia episodes greater than 5 was associated with an insulin dose > 0.77 IU/kg/day but this association was not significant. The p-value was equal to 0.9 and the odds ratio 1:1.

There were more hypoglycemias in patients using human insulin but this association was not significant (p = 0.9) (**Table 3**).

There was no significant association between the injection site and the occurrence of more hypoglycemic episodes. Sports practice was not associated with hypoglycemia. The odds ratio was 0.55 and the p-value was 0.5 (**Table 3**).

4. Discussion

We noted a high prevalence of hypoglycemic episodes of 34.5% and a prevalence of severe hypoglycemia of 18%. It has been described that symptomatic hypoglycemia occurs on average 2 episodes per week with several such episodes during life. Indeed, studies have reported that 6.2% of children experience at least one episode of severe hypoglycemia per year [6] [7].

The number of hypoglycemia episodes greater than 5 was associated with young age in our cohort, *i.e.*, those under 15 years of age. In the literature, severe hypoglycemia is more common in younger children [8]. The incidence of hypoglycemia has been reported to decrease significantly with age [9].

Male gender predominated in our study with a sex ratio of 1.2. However, there was no significant association between the number of hypoglycemic episodes and gender, although the risk was 1.8 times higher in the male population. Studies have reported a male predominance in pediatric T1D [10].

Access to health care can be a big challenge for children from poor families even more so in developing countries [11]. The majority of our patients were from a family with a low socioeconomic level. But we did not find a significant association between socioeconomic level and hypoglycemic episodes.

The diagnosis of hypoglycemia was made in children aged 18 - 24 in our cohort. Only 13.2% of patients were under 5 years of age. In France, a study found similar results [12].

In the literature, the longer duration of diabetes is a non-modifiable risk factor for severe hypoglycemia [3]. One study reported that the hypoglycemic subgroup had a longer duration of diabetes and that a longer duration was a significant but weak predictor of hypoglycemia [13]. More than half of our patients had a duration of diabetes of less than 5 years. Therefore, recent diabetes. Only 16% had a longer duration of more than 5 years. We found a very significant link between the duration of diabetes and the number of hypoglycemic episodes. In other words, the more recent the duration of diabetes, the greater the number of hypoglycemic episodes. However, no correlation was found between the incidence of hypoglycemic episodes and the duration of diabetes in the Bognetti study [9].

Human insulin was used in the majority of cases in contrast to Modern Insulin.

Available paediatric studies do not appear to support the suggestion that human insulin impairs the perception of hypoglycaemic symptoms ("hypoglycaemic unawareness") and increases the frequency of hypoglycaemic episodes, but further conclusive studies are needed [14]. The risk was higher in those using human insulin but there was no significant association between insulin type and increased number of hypoglycaemic episodes.

We found that 87% of our patients had a daily insulin dose less than or equal to 1 IU/kg/day with a mean of 0.77 IU/kg/day ± 0.23 IU/kg/day. We did not find a link between the insulin dose and the occurrence of hypoglycemic episodes even if there were more hypoglycemias in patients whose dose was greater than 0.77 IU/kg/day. In Robert's study, the median dose for the hypoglycemic group was (1.0 U/kg/day) and was higher ($p < 0.05$) than for the non-hypoglycemic group (0.89 U/kg/day) [13]. Most studies have demonstrated that the incidence of severe hypoglycemia increases in patients receiving intensive insulin treatment [15]. In contrast, some other studies have found a low incidence of hypoglycemia despite intensive treatment [16].

In our cohort, we observed that 26% of our patients had a special diet, *i.e.*, had dietary restrictions with a limitation on certain types of foods such as rice, which is the main food in our country. But almost all of our patients had 3 meals per day. Nutritional advice should be adapted to the cultural, ethnic and family traditions and psychosocial needs of each child [17]. Regular meals and routines where the child and family sit and eat together help establish better eating practices and monitor food intake, which have been shown to be associated with better glycemic outcomes [18] [19].

Physical activity is important for diabetes management and has the potential to delay cardiovascular disease [20]. Young people with type 1 diabetes are advised to participate in physical activity with appropriate insulin and dietary adjustments [21]. Written advice on exercise and sports should be included as part of the school management plan for caregivers/teachers [22]. Meta-analyses have identified significant effects of physical activity on reductions in HbA1c, BMI, triglyceride levels and total cholesterol, reinforcing the importance of physical activity in the clinical management of diabetes to delay or reduce the risk of microvascular complications [20]. The majority of our patients (66%) were physically or sportingly active. Despite this, no cases of severe hypoglycaemia were reported following physical activity. The link between physical activity and the occurrence of hypoglycemia was not established. However, studies indicate a fear of hypoglycemia in young people with type 1 diabetes and their parents during physical activity [20].

We noted that only 21% of our patients had reached the target HbA1c level (7.5%). The rest of the patients were unbalanced 15.8% with a high level greater than 13%. There did not seem to be any correlation between hypoglycemia and the variation in HbA1c levels between two semesters. Similarly, Mortensen in his study reported that the frequency of hypoglycemia in eight centers with the lowest

mean HbA1c values was not different from that in eight other centers with the highest mean HbA1c values [23].

The majority (68%) of patients and/or their parents had a fear of hypoglycemia because they were aware of its seriousness. But others had reported the fear of hyperglycemia rather than following hospitalizations for ketoacidosis. The occurrence or fear of hypoglycemia is considered the main obstacle to better glycemic control [24]. The majority of studies do not demonstrate any association between glycemic control and fear of hypoglycemia. However, a small number of studies have found a positive association between parental fear and children's glycemic control [25].

We found 7 cases of severe hypoglycemia in 18% of patients. The manifestations were neurological disorders, namely coma, drowsiness and obtundation; we did not find any convulsions. Among these patients, 4 had a history of severe hypoglycemia. It has been reported that in the event of severe hypoglycemia, the risk of another severe hypoglycemia occurring within five years is 80% [26]. The age of these patients was over 15 years in 5 cases, *i.e.*, 71.4%. However, in the first international comparison of the "Hvidøre Study Group on Childhood Diabetes", carried out in 1995 in children under 18 years of age, severe hypoglycemia was more frequent in the youngest children (<8 years of age) [3].

Hypoglycemia occurred mainly on waking and at midday in our study. Our patients are therefore at risk of nocturnal hypoglycemia which constitutes a danger ("dead-in-bed" syndrome). The "dead-in-bed" syndrome would thus explain, according to the series, 22% to 45% of deaths from unexplained causes in young type 1 diabetics [27] [28].

The main risk factor for hypoglycemia is a mismatch between insulin and the amount of food consumed. Excess insulin could also result from an increase in doses due to a poor understanding of the type and action of insulin, reduced food intake or no carbohydrates or in insufficient quantities, a forgotten or delayed meal but also after exercise where glucose use is increased [2] [29]. The circumstances of occurrence most found in our case were after a sports activity (mainly aerobic), a delayed meal intake and then an insufficient meal intake. When a diabetic child participates in vigorous, prolonged or unusual physical activity, there is a risk of hypoglycemia during and up to 2 to 12 h after exercise [30]. Purely aerobic physical activities tend to lower blood glucose levels both during (usually within 20 to 60 minutes after the start) and after exercise [31]. In a study of the effect of aerobic exercise on blood glucose levels in children with T1D, 83% of participants experienced a decrease in blood glucose levels during exercise, and 30% became hypoglycemic during or immediately after exercise [32]. In 2 patients, we noted 2 cases of insulin injection without a meal and 5 cases of insulin overdose. Bognetti found similar results to ours with dietary errors (delay or decrease in food intake) in 27% of cases. He also reported that 12.2% of cases occurred during physical exercise performed without adaptation of the insulin dose or food, and an explanation was not found for 50% of hypoglycemias [9] [33].

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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