

Assessment of Growth among Children with Type 1 Diabetes Mellitus: A Cross-Sectional Study of Factors Contributing to Stunting

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Received date: March 08, 2018; Accepted date: March 26, 2018; Published date: April 2, 2018

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Abstract

Introduction: Diabetes is a worldwide health challenge. Research done among diabetic children concluded that the abnormalities in growth associated with diabetes are due to reduced insulin use and are reversible with adequate insulin therapy. A diabetic child who is on appropriate treatment should have no impairment of growth. In this study, we assessed the prevalence of stunting among a population of pediatric patients with diabetes.

Methods: It is a descriptive cross-sectional study done from September to December 2015 in Rwanda. 136 children from 23 districts were included. Patients aged 1 to 18 years old were enrolled. Weight, height and Glycated hemoglobin were our study parameters. Stunting was defined as height for age below -2SD. Previous HbA1c readings were obtained from patient files. Interviews were used to code demographic, socio-economic factors, access to and affordability of food and clinical data information. Data entry was done in Epidata and analyzed by Stata 13.

Result: 136 children were enrolled, aged 2 to 18 years with a mean age of 15.5. 39.7% were male and 60.3% were female. The prevalence of stunting was 30.9%. The mean HbA1c was 9.7%; 28% were well controlled with an HbA1c <7.5, whereas 41.2% had a poor glycemic control with HbA1c of 10% or above. Those with lower socio-economic status were better controlled. The mean daily Insulin dose was 0.8 IU/kg/day. Regarding availability of meals, 4.4% reported to have only one meal per day. 34.6% admitted their nutrition was inadequate. No secondary school education for parents was associated with stunting. Districts Huye and Rusizi were the most affected with stunting. Insufficiently fed children were likely to be stunted.

Conclusion: The prevalence of stunting among children with diabetes was high. There was no association between stunting and glycemic control, but there was an association between stunting and poor socio-economic condition.

Keywords: Diabetes; Malnutrition; Stunting; Glycated hemoglobin; Insulin; Districts

Abbreviations CDC: Center for Disease Control; DHS: Demographic Health Survey; DKA: Diabetic Ketoacidosis; GH: Growth Hormone; HbA1c: Glycated Hemoglobin; IDF: International Diabetes Federation; IGF: Insulin-like Growth Factor; IGFBP: Insulin-like Growth Factor Binding Protein; NCD: Non-communicable Diseases; RDA: Rwanda Diabetes Association; T1DM: Type 1 Diabetes Mellitus; UNICEF: United Nation Children's Fund

Introduction

Background

Diabetes is the most common pediatric endocrinologic disorder [1]. It is a disorder in which the pancreas is unable to produce enough

insulin that is needed by different cells of the body to maintain normal glucose metabolism [1].

The prevalence of diabetes has increased worldwide. Type 1 Diabetes mellitus (T1DM) is a global public health challenge [2]. According to the 2012 IDF atlas report, an estimated 480,000 children, aged 14 and under, are thought to have diabetes, with 77,000 new cases being diagnosed each year. T1DM has been increasing over time with a higher incidence in western countries than in Sub Saharan Africa [3].

The prevalence of diabetes has increased even faster in low resource settings, especially in urban areas [4]. Current estimates in Africa state that, as of 2010, 35,700 children have T1DM, with 5,800 new cases diagnosed each year [5]. There are few data on T1DM prevalence in children specific for East Africa.

Diabetes management in children is complicated, and requires good long-term care with close follow-up and compliance with treatment. Complications of diabetes include diabetic ketoacidosis (DKA),

hypoglycemia, and long-term complication such as nephropathies, retinopathies, hypertension, and growth impairment [6].

Now that Rwanda has reduced mortality rate associated with communicable disorders, more efforts are being placed on non-communicable diseases (NCD) [DHS 2010]. The WHO reports that patients with diabetes require up to triple the healthcare resources when compared to those without diabetes [2]. The burden of diabetes is a significant issue, especially in the developing world where the cost of medication and access to laboratory tests make it heavy to bear given the underlying poverty and limited access to food [2]. There has been a lot of improvement in diabetes management in the developed world over the last two decades, but there has been no or little improvement in developing world [7,8].

Children with diabetes are expected, with proper nutrition and care to attain normal nutritional status and growth [9,10]. One sign of poorly controlled diabetes is poor longitudinal growth and development. Growth impairment is a well-known complication of DM1 as described in several studies [6,9,11]. It is associated with poor glycemic control, along with other complications such as microalbuminuria, as described by Marcovecchio [11].

In a 2010 study by Marshall of Rwandan patients with diabetes below 25 years old, performed through the Rwanda Diabetes Association, the same site as in this study, it was found that glycemic control was poor with mean glycated hemoglobin HbA1c level of 11.2% \pm 2.7%. Approximately 30% of participants had an HbA1c $>$ 14% and only 15% had an HbA1c $<$ 8%. The mean HbA1C decreased to 9.8% \pm 2.6% after 2 years of follow up, showing some improvement but also revealing that more education was still needed [7]. There is paucity of data regarding pediatric diabetes mellitus in Rwanda, both for prevalence, complication and mortality rate.

Nutrition is the cornerstone in management of diabetes [1,6]. The use of insulin depends on absolute availability of glucose, thus nutrition. Otherwise, there is an increased risk of hypoglycemia [6]. With conventional insulin therapy, which is the regimen that is used the most in Rwanda [12], children and adolescents need at least 3 regular meals plus snacks according to the pharmacokinetic of the common insulins used. The need for adequate nutrition is paramount for every patient with diabetes with special consideration in a developing child and even more during puberty [6,13]. In addition to diabetes, Rwandan children and the general population face issues of access to food.

Malnutrition is highly prevalent in Rwanda. The last DHS (Demographic Household survey) in 2014 showed that 38% of children under age five suffer from chronic malnutrition [14]. Strategies have been put in place to strengthen nutrition at the community level to try to reduce the occurrence of malnutrition with the help of some international organizations such as UNICEF [15-22].

Rational of the study

This study aims to assess the growth parameters of children followed in the Rwanda Diabetes Association clinic located in Kigali as no similar study has been conducted in Rwanda. It is a pilot study designed to help us understand the current situation, so that we will better be able to understand and address the factors associated with poor growth. With results of this study, we will generate recommendation to help health professional provide the best care. This study can be used as an evaluation tool for pediatricians and general

practitioners and medical teams in general taking care of children with type 1 diabetes mellitus.

Research question

Do children aged 1-18 with type 1 diabetes followed at Rwanda Diabetes Association grow within the expected 2 standard deviation from the mean, according to WHO growth chart? Is there a relationship between stunting and glycemic control?

Literature Review

Growth and diabetes

The growth hormone is responsible for growth in a developing body. It has a pulsatile secretion varying throughout the day. Its action requires some other component and modulators such as insulin-like growth factors and insulin [23].

Insulin-like growth factors (IGF) are mediators of growth hormone-stimulated somatic growth and growth hormone independent anabolic response. IGF-1 is involved in DNA synthesis, protein synthesis, cells size and inhibition of apoptosis.

Minimal intake of 20 kcal/ kg/ day and 0.6 g/kg of protein are enough to maintain sufficient levels of IGF-1 in the blood. Malnutrition decreases the level of IGF-1 which decreases sensitivity to growth hormone and results in altered growth [24].

Insulin intervenes in IGF production. The decrease of insulin in the blood will decrease the production of IGF by the liver and alter the production of IGF binding protein. As observed with malnutrition, there will be disturbances with IGF-IGF BP axis and the usual anabolic response will be decreased [23]. Insulin administration can reverse this process as has been shown in previous studies [23,25].

Definitions

Type 1 diabetes mellitus (T1DM): One of the most common chronic diseases in childhood is caused by insulin deficiency after destruction of the insulin-producing pancreatic beta cells. T1DM remains the most common form of diabetes in childhood [6,16].

Insulin: A peptide hormone that is released by β - cells located in the Islets of Langerhans of the pancreas. Insulin is used by the liver, muscle and adipose cells; to extract glucose from the blood, and convert it into energy at the cellular level [6].

Conventional therapy: Insulin given in 2 injections of mixture of long-acting and rapid-acting insulins, typically a third of regular insulin, 2/3 of intermediate insulin, morning and evening injection, 2/3 in the morning 1/3 in the evening [6].

Basal bolus therapy: Insulin given as a daily basal long-acting form with boluses of short-acting insulin with meals [6].

Glycated hemoglobin (HbA1c): HbA1C is a laboratory test that shows the average level of blood sugar (glucose) over the previous 3 months, measures the hemoglobin that has bind to glucose. The normal value should be 4.5-5.6%, when at risk for diabetes 5.7-6.4%. Children with T1DM should have a level less than 7.5% to be well controlled.

Stunting: Failure to attain optimal linear growth, defined as height below 2 standard deviation from mean height. Stunting is an indicator

of chronic malnutrition. It is severe when the height for age is below -3 standard deviation, between -2 and -3 SD is classified as moderate stunting

Ubudehe: A home grown development program whereby citizens are placed in categories according to their socio-economic level. These categories also determine the social support the family will receive from the government.

Aim and Objectives

Aim

To evaluate the growth and glycemic control of children and adolescents with diabetes in order to identify factors which may lead to sub-optimal growth.

Objectives

- To assess the rate of growth impairment among children living with diabetes followed at Rwanda Diabetes Association clinic and to look for association with glycemic control.
- To establish whether there is an association between poor growth and duration of diabetes.
- Understand the distribution of HbA1c in children with DM type 1.
- Explore whether there is an association between stunting and social economic factors such as parental education level, access to food, access to health facility, having a glucometer, regular supply of blood sugar strips and other appropriate supplies for diabetes care.

Material and Methods

Study design

This was a descriptive analytical cross sectional study.

Study site

The study was conducted in conjunction with Rwanda Diabetes Association (RDA) clinic, located in Kigali, the capital of Rwanda. Through RDA, patients receive support for care, free medical follow-up, insulin, syringes, a glucometer when available, and laboratory investigations. In this clinic, there is daily consultation available with a general practitioner, either on an appointment basis or as a walk-in. Referrals or consultation with an endocrinologist are requested for special circumstances when needed. There are doctors, nurses, social workers, and a nutritionist taking care of patients. They have also rooms for admission. More than 800 children and young adults from different parts of Rwanda are being followed on a regular basis. 270 children and adolescents were in the age range of this study. The treatment protocols used are conventional insulin therapy or long acting insulin (*Lantus*®, *insulin* glargine) with rapid-acting boluses with meals (basal-bolus therapy). Children who are stable are evaluated every 3 months with weight and height measurements, blood pressure, HbA1c measurement, urine for albuminuria, and renal function test, as well as annual ophthalmology screening. Children who are poorly controlled get more frequent follow-up. They are educated about diabetes, nutrition, complications, treatment principles, and the need for regular follow-up. Recently the clinic

initiated a camp for adolescents where they are taught about diabetes for 6 months during an intensive training.

The RDA works closely with different district hospitals in taking care of these children. There is education being done in different hospitals staffed by a nurse responsible for chronic diseases and with set days dedicated for chronic diseases consultation, among them diabetes. On that consultation day, they have 30 minutes to 1 hour talk about a disease. In case of diabetes, they are taught self-monitoring, nutrition using available food in the region, “red flags” and emergencies of diabetes and what to do when it happens. The patients have opportunity to ask all questions they might have.

Study population

All children from 1 to 18 years old from all districts in Rwanda, diagnosed with type 1 diabetes mellitus, followed by Rwanda Diabetic association clinic and seen during the study timeframe were considered for this study.

Inclusion criteria

Children with type 1 diabetes mellitus from 1 to 18 years old on treatment, who are being followed by the Rwanda Diabetic Association clinic in Kigali, Rwanda who presented for follow up in September-December 2015, were included.

Exclusion criteria

Children with other chronic diseases that could affect growth, such as celiac diseases, Addison disease, thyroiditis HIV/AIDS, renal failure were excluded from the study.

Children refusing to consent or parents refusing to sign consent form were also excluded.

Main exposure confounder outcome measured

The exposure is glycemic control in response to insulin. We used HbA1c as proxy for glycemic control.

The primary outcome is presence of stunting, defined as height for age below 2 standard deviation from the mean on WHO growth charts. Underweight was defined as weight for age below 2 standard deviation of the mean on WHO growth charts.

Potential confounders identified were familial stunting, comorbidity and poor growth from other chronic diseases. We tried to minimize these by excluding the children with other known chronic diseases affecting growth.

Procedure at enrollment

After the parents have signed a consent form and the child has given assent, one time anthropometric measurements were obtained. The height without shoes measured. Length was measured for infants. Weight and height were plotted using WHO growth charts, weight for age and height for age. Those with height for age below -2SD were designated as “stunted” Those above were designated as “normal”.

HbA1c was measured by a trained technician on a “Siemens DCA Vantage” machine and more information was gathered through interviews to fill the questionnaire Previous HbA1c from 2015 was recorded from patients’ files.

Data collection

Demographic and clinical information, age, sex, address, parents' level of education, ubudehe class, number of meals per day, self - evaluation of nutrition adequacy, insulin dose, insulin regimen, age at diagnosis, were taken from clinical chart, and from interviews.

Data were de-identified for patient privacy, then entered in Epidata and encoded and cleaned.

Statistical analysis

After collected data were entered using EPIDATA, data were analyzed using Stata 13.0 software. Microsoft Word was used to create text and generate tables and graphs.

We ran summary analysis for descriptive analysis and prevalence, CHI square test was used to look for association in two by two variables. Test for correlation, logistic analysis were used for multivariate analysis.

Ethical considerations

All collected data were de-identified by assigning unique study numbers to each enrollee. The identifiers were kept in a separate location and only accessible to the Principle investigator. All results were kept confidential and only transmitted to the treating team to be used for treatment as indicated. Written informed consent in Kinyarwanda was obtained from parents or caregiver and written assent from children before enrollment. Parents and patients were explained that they have the choice to refuse enrollment in the study without impact on the quality of care given. The study was conducted after approval by ethic committee and the scientific committee of University of Rwanda and by ethic committee of RDA.

Results

Descriptive analysis

Of the expected 270 children and adolescents only 136 came for follow up during the study period, were eligible and accepted to participate in the study. Ages ranged from 2 to 18 years old the mean was 14.3 years (+/- 3.6). 39.7% were male and 60.3% were female.

Majority of parents completed primary school (60.3%). 14% were never in school, 19.1 % had high school level and 6.6% have university degree.

With regard to availability and affordability of meals, 36.3 % and 35.6% have 2 and 3 meals per day respectively; 4.4% report to be able to have only one meal per day, 23.7% had 4 meals per day. When asked about how they feel the nutritional status of the child/ adolescent, 47 (34.6%) felt that the nutrition is not adequate and 65.4% felt their nutrition was adequate. On open ended questioning, 46 of these 47 reports that they cannot afford appropriate food.

22 children were diagnosed within the year of the study (were newly diagnosed). The mean duration of diabetes was 2 years (+/-2.46). The mean age at diagnosis was 11.6 years old (+/- 4.3), 73.5% were diagnosed aged 10 years and above. There were 4 children who were diagnosed around 1 year of age. The follow up was monthly in 47.8%, and once in 3 months in 50% of cases.

The total daily dose of insulin ranged from 0.4 to 1.7 IU/kg/day. The mean dose was 0.8 IU/kg/day (+/- 0.27). By the time of our study, one

person had stopped treatment because there was no insulin available at the hospital and he did not have money to buy in private. 91.9 % were using conventional therapy and 5.9 % were using basal-bolus therapy.

92.6% reported that they could afford medication; 83.8% have glucometer and 74 % have glucometer strips regularly.

In review of measured heights, 30.9% were stunted: 24 (17.7%) were moderately stunted and 18 (13.2%) were severely stunted (Table 1).

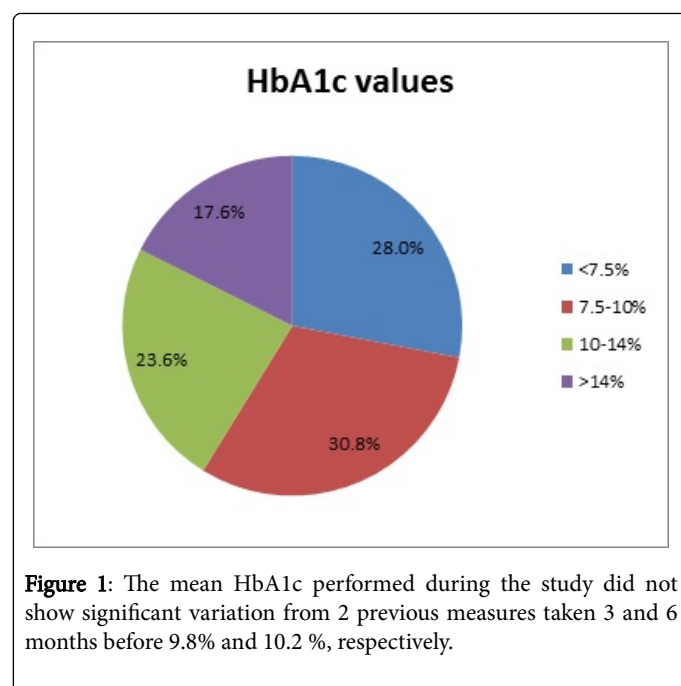
		Frequency	Percentage
Sex	Male	54	39.70%
	Female	82	60.30%
Age	2-5	6	4.41%
	6- 9	10	7.35%
	10- 18	120	88.24%
Underweight	Yes	45	33.10%
	No	91	66.90%
Stunting	Yes	54	39.70%
	No	82	60.30%
Ubudehe	1	19	14%
	2	74	54.40%
	3	42	30.90%
	4	1	0.70%
Level of education	None	19	14
	Primary	82	60.3
	Secondary	26	19.1
	University	9	6.6
	Follow up Once monthly	65	47.80%
	Once every 3 months	68	50%
	Once every 6 months	1	0.70%
	Less that once in 6 months	2	1.50%

Table 1: Descriptive table.

Study results

In review of height data, 30.9% were stunted, 24 (17.7%) were moderately stunted and 18 (13.2%) were severely stunted.

The mean HbA1c was 9.7% (+/-2.7). 28% of patients were well controlled with an HbA1c <7.5, 30% had intermediate control with HbA1c between 7.5 and 10 % whereas 41.2% had a poor glycemic control with HbA1c of 10% and above, including 24 (17.6%) had HbA1c >14, the upper limit for the machine (Figure 1).



Factors associated with stunting

There was no association found between stunting and age, nor parents being deceased. There was no association found between glycemic control and stunting, nor with duration of diabetes. There is no association between stunting and regular use of glucometer (Table 2).

Variables	P values
Sex	0.016
District	0.044
Ubudehe	0.002
Level of education	<0.001
The number of meals per day	0.008
Self-assessment of dietary adequacy	0
HbA1c	0.758

Table 2: Association found with stunting in univariate analysis.

The correlation test shows that the number of meal was correlated with level of education and ubudehe class, and with district (Table 3).

Variables	P value
Level of education of parents	0.024
Sex	0.008
Self-assessment of dietary adequacy	0.001

Table 3: Associations found with stunting in a multivariate model.

Having a level of education below secondary school was associated with being stunted. Female were less likely to be stunted than male (OR 0.3). The feeling from the responders that the nutrition was not adequate was associated with stunting.

Factors associated with glycemic control

There was no association found between glycemic control and age, number of regular visit, affordability of medication, duration of diabetes or age at diagnosis. The glycemic control was not dependent on where participants live.

There was an association between ubudehe class and glycemic control. Being in ubudehe class 1 (which is the lowest socioeconomic class) was protective from having poor control (OR=0.3 p=0.012). High total daily dose insulin (0.7 IU/kg/day and above) was associated with having poorly controlled glycaemia (OR=2.4 p=0.047)

Discussion

In a classification done by the World Bank in 2006, Rwanda was among 10 countries with highest stunting rate. Burundi was the first with 57%, followed by Zambia (50%), Malawi (48%), Madagascar (48%), Ethiopia (47%) then Rwanda (45%). Rwanda was the second most affected by stunting in the region. In a similar study published by World Bank in 2007, the prevalence of stunting was 30% in Kenya, 39% in Uganda and 38% in Tanzania, with Burundi being the highest at 57% [26].

The recent DHS 2014-15 report revealed 38% of stunting among general population under age 5 in Rwanda [14], decreased from the previous report DHS- 2010 when it was 44%, but still high. In our study population, most of our participants were above 5 years, We could not assess stunting in children less than 5 years because our sample size was too small in that age group with only 4.4% being under 5 years. Our sample was mainly in adolescent range with few young children, making the chi test not applicable.

There is little in the literature discussing stunting in adolescents and specifically among children and adolescents with diabetes mellitus. In one study done by Khadikar in Indian found the prevalence of stunting among diabetic children to be around 27.1% [20], lower to what we found in this study, in their study, their population included also adolescents, the mean age of their population was 9.7 years.

Stunting was inversely associated with the level of education of the parents: having a secondary school level was protective. Similar results were found in the Rwanda DHS 2014-15 done among children under 5, where lower level of education was associated with high rate of stunting [14]. In Uganda, a study done by Kikakunda showed similar result [27,28].

Children with poor social economic conditions have limited access to food, which is a well-known and understandable cause of stunting. Similar results were found by Patricia Silva in a study done in Ethiopia, a country that has also a high rate of stunting (47%). She found that poor socio-economic condition was associated with stunting [27]. Another study done in Uganda by Kikakunda was able to find association between low socio-economic status of family and stunting, and also association with level of education of the parents [28]. These are similar to the results found in this study. We found that having a parent or caretaker with a level of education less than high school was associated with being stunted.

Even though the socio-economic condition are limited in many rural Rwandan household, the family that has a child with diabetes faces even greater challenges since the insulin injection absolutely requires availability of food. There are also the health services cost related to diabetes itself. Monthly or every 3 months follow-up will involve money for transport to the hospital which can be far and costly, money for insulin (when the donation are not available) and a day off from work while accompanying the child to the hospital. In some associated condition and complication requiring long time admission, it can be a very difficult time for families where the bill of the hospital increases and the time and opportunity to work decrease while attending. From an economic point of view, it is a time-consuming and less productive period. In an already poor family, having a child with diabetes maybe is even more challenging. Further study is required to evaluate the actual impact of diabetes on the daily life of limited resourced families.

In this study we found that when the parent or adolescent was estimating the nutrition to be inadequate, this was strongly associated with being stunted. During interviews with some of participants, when asked how many meals they have per day, they answered “*I eat 2 times a day but the rest of the family eats once a day*”. One hypothesis is that, given the limited availability of food and after being educated on the importance of taking medication only after eating, many families reserve some food for the child with diabetes to be able to give him/her insulin. 36.3% had 2 meals a day and 4.4% had 1 meal per day this is not adequate nutrition for a child with diabetes treated with insulin.

In a univariate analysis, the markers of socio-economic condition, such as number of meals, were associated with stunting with a significant p value. However, with multivariate analysis the association was not statistically significant, probably due to confounders.

As determined through interviews, participants knew the recommendation about nutrition of their children but not all of them were following those recommendations in daily life. A third of our population says that they do not give recommended food to their children because of poverty.

There was no association with stunting and frequency of follow up, regular use of glucometer. No association between stunting and duration of diabetes this may be explained by the fact that the mean duration was 2 years, which may be considered as a short period for a chronic disease like diabetes to impact on growth.

There was no association between stunting and glycemic control, similar result was found by Khadika in a study done in Iran. He found that the glycemic control did not influence the growth of children with diabetes [29]. In a study from 2004, Chiarelli concluded that a child / adolescent diagnosed with diabetes mellitus can achieve expected height when on adequate insulin therapy [25,30]. All our participants were followed by RDA we can suppose they have a good follow up. This may be seen as selection bias which may be a reason for lack of association between stunting and diabetes mellitus. On the other side there is a high rate of stunting in the general population, the study population may not be large enough to detect the added effect of glycemic control. In studies that have been able to establish an association between stunting and diabetes control, there has been a correlation with longer duration of diabetes [20]. In this study the mean duration of the disease was about 2 years this may explain why we were not able to have an association. The second association often found in literature is due to younger age at onset of diabetes; in this study 75% were diagnosed when aged 10 years and older and up to

50% were diagnosed after onset of puberty, and we know that the effect of diabetes on growth after onset of puberty is low [20]; this may also explain why we did not find an association between diabetes control and stunting. In literature, even though HbA1c is a good marker of chronic control of glycaemia, there is recognized limitation to this test, this test is subjected to influence of several medical conditions such as abnormal hemoglobin traits, hemolytic anemia, recurrent malaria, other infections or other conditions with increase turnover of red blood cell. Maybe this marker was not the most sensitive in detecting the association of stunting and glycemic control. A longitudinal study on a much large population would give more information on the question.

In this study the mean HbA1c was 9.7%. In the study done previously by S Marshal in 2010 at RDA, the mean HbA1c was 9.8%. Therefore there has been some improvement in overall diabetes control with only 15% were well controlled in 2010 and now 28% are well controlled in 2015. In 2010, 30% had HbA1c >14%. Currently 17.6 % have HbA1c >14%, almost decreased by half. While this is promising, there is need for more improvement because in this study 41% remain poorly controlled (HbA1c >10). There has been some improvement, but there is still a long way ahead of us [21]. In a study done in Kenya by Thomas Ngwiri, among children and adolescent age 1 to 19 years old, the median HbA1c was 11.1% with about 28% of the population with HbA1c 8% or below. These results are almost similar to our study with a small proportion well-controlled but their median was higher than the median found in this study [29]. In another study done by Khadikar in Iran, the mean HbA1c was 8%, with 37.5 % well-controlled. 20.5% had poor control, which is half of what we found in our study [30].

In this study, we found that being in the lower socio-economic class established by Local authorities also called ubudehe class was protective from having uncontrolled glycaemia (OR 0.29 p=0.047). One possible hypothesis is that children in this class do not have access to nutrient-poor, high calorie food and have less variability in their diet allowing for easier titration of their insulin. They have no access to high sugar and fatty containing food. Most have 100% insurance (*Mutuel de santé*) which may explain why they had good control compared to the rest of the population.

This contrast other studies such as that by Hassan in 2006 in Iran where they found poor social economic status to be a risk factor for having poor glycemic control (HbA1c >8) and also being associated with low quality of life and depression [30]. In another study performed in United States of America comparing glycemic control in Hispanic and non-Hispanic adolescents with type 1 diabetes mellitus, they found that there was poor glycemic control in Hispanic compared to non-Hispanic whites because there were poor socio economic status. The health insurance rate was low, and there was a low level of parents' education in Hispanic youth. So the difference in glycemic control was associated with poor socio-economic condition [31].

Having a high dose of insulin was associated with being poorly controlled. This was paradoxical result; one would expect a better control when on insulin therapy as found by Ngwiri [29]. This may be due to poor adherence or some undiagnosed comorbidities such as autoimmune diseases, malabsorption disorder

We were not able to test for association between glycemic control and different age group because we had a small sample in children of young age. Our population was composed mainly of adolescents.

In this study, males were more likely to be stunted than female. This was also found in Rwanda DHS 2014 while screening children under five [14], where male were more affected than females [14]. Similar result was also found in a study done in Ethiopia [32].

We had some limitations with this study:

Among participants that we were expecting only half of them presented during the study period, we missed the other half.

Given the limitation of time the questionnaire used for nutrition was subjective and not validated where we considered the opinion of the participants and their care taker.

Since this was an unfunded study we could not afford case control study so we choose a more feasible and less costly cross sectional study with a big disadvantage of time line we cannot establish good association or know what the risk factor is, what is the outcome? Another limitation with this design is that one measurement is not optimal for measuring growth; longitudinal study would measure growth velocity and give more complete answers.

Summary

In this study, we assessed the growth among children with diabetes, and tried to identify factors that can influence growth velocity and cause stunting in this particular population. Our goal was to help determine areas requiring further evaluation as part of their management.

This study was conducted among children with diabetes followed by Rwanda Diabetes Association. Diabetes is a worldwide public health challenge, which is highly costly all over the world in general, in Africa and in Rwanda as well. Prior studies were able to prove that diabetes will not interfere on growth once on insulin and optimal glycemic control is achieved.

Stunting is prevalent in Rwanda with a reported high rate in the general population under age 5, though there is no report in older children. However, there is no data on the effect of chronic disease such as diabetes on growth, particularly in those at risk due to poorly controlled disease. In this study, we had a particular interest in this group of children and adolescents with type 1 diabetes to assess their growth, as well as their level of glycemic control as measured by glycated hemoglobin.

We looked at the association of stunting and several factors such as glycated hemoglobin, duration of diabetes, social economic conditions, and demographic data. We looked for associations of glycemic control and duration of diabetes, insulin therapy regimen used, and socio-economic conditions.

Our study describes the current situation of Rwandan diabetic children's growth, by assessing their height. Among children with stunting we wanted to see if this could be associated with their level of glycemic control using their glycated hemoglobin and identify the most vulnerable and then be able to propose recommendation for better care and better outcome in these children and adolescents.

Conclusion

There is a high prevalence of stunting seen among the children and adolescents followed-up for type 1 DM. The stunting is associated with poor socio-economic condition, low level of education and limited affordability of food. One third of participants reported that they have

limited affordability of food. The more affected areas are the South and South-west of Rwanda.

Even if there has been some improvement on glycemic control, we still have a long way ahead. At present, only a quarter (28%) of our participants was well-controlled and we have high rate of poorly controlled children and adolescents. The mean HbA1c in our study was 9.7%.

The glycemic control was associated with ubudehe class: the class 1 of ubudehe (lower-socio economic class) was associated with better control. Those who required a high dose of insulin, 0.7 IU/kg/day and above, were likely to have uncontrolled diabetes. There was no relationship between duration of diabetes and glycemic control.

The stunting in this population was not associated with the glycemic control, implying that diabetes itself was not a significant influence on stunting in this study.

Recommendation

Our first recommendation is to put in place a program to help families, to build their capacity in a more sustainable way, with much effort devoted to poorer families with sick children, starting in those more affected district such as Rusizi and Huye. Follow up should also be focused on programs already put in place by the Rwandan government, like *Girinka munyarwanda, uturima tw'igikoni*.

Families where the parents did not attend high school should be monitored more closely since this has been associated with stunting. For the coming generation, we should discourage people from dropping school.

We recommend also regular survey every one or two years to assess the glycemic control of the diabetes population in Rwanda to evaluate for improvement.

Further research is needed including longitudinal prospective cases control studies to assess longitudinal growth and to further evaluate the influence of glycemic control on growth in diabetes population.

Studies about the impact of diabetes mellitus on families with limited resources would also be valuable in order to better understand the challenges faced and establish a plan of care appropriate to this population.

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