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Impact of Health Education Program for Management of Diabetes Ketoacidosis on Physician Awareness

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Abstract

Background: **The outcomes of DKA patients could be significantly boosted by raising the physician's suspicion of early symptoms, effectively managing the ongoing DKA condition or its complications as soon as possible, and closely monitoring the controlled patients. Several studies have evaluated the role of interventional programs in improving physicians' knowledge regarding DKA.** ***Aim:*** **We aimed to assess the impact of implementing a health education program based on the ISPAD 2014 guidelines on improving pediatricians' awareness and knowledge of DKA diagnosis, management, and complications in children.** ***Subjects and Methods:*** **This was a quasi-experimental (pre-post interventional) study conducted at EL Nasr Hospital, Port Said, Egypt. The study included 28 pediatricians and their knowledge was assessed prior to and following the education program.** ***Results:*** **In general, the education program has significantly increased pediatricians' scores when assessed just after and 3 months following the program (P<0.001). Interestingly, we found that the scores of male pediatricians were significantly higher than their female counterparts only in the pretest test (p=0.017). Meanwhile, the differences in scores between different post-graduation degrees at different time points were insignificant. Moreover, physicians' knowledge was not correlated with their age or the duration of their experience.** ***Conclusions:*** **The educational program has boosted the pediatricians' knowledge regarding DKA diagnosis, monitoring, complications, and treatment.**

Keywords: Diabetes, evaluation, knowledge, doctors

Introduction

Since it is a frequent endocrine and metabolic disorder affecting children, Type 1 diabetes mellitus (T1DM) has come to the attention of the public health community. T1DM, which accounts for almost two-thirds of newly diagnosed cases of diabetes in children and adolescents, continues to be the most prevalent type of the disease in childhood[(1,2)]. T1DM is considered a major health issue since it can lead to potentially life-threatening consequences, particularly diabetic ketoacidosis (DKA). A diabetic youngster may manifest with DKA, a metabolic disorder made up of the triad of hyperglycemia, ketonemia, and metabolic acidosis[(3)]. Therefore, pediatricians should focus on preventing

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DKA and its effects while treating children with T1DM. This objective can be met by alerting the doctor to early signs, promptly addressing the ongoing DKA disease or its complications, and closely monitoring the controlled patients, all of which will improve the outcomes for DKA patients[4,5]. The effectiveness of interventional programmes in enhancing doctors' understanding of DKA has been assessed in a number of studies [6, 7]; however, there is a dearth of information available in Egypt. In order to reduce complications and improve outcomes for diabetic children, we, therefore, conducted this study to evaluate the effect of implementing a health education program based on the ISPAD 2014 guidelines on pediatricians' awareness and knowledge of DKA diagnosis, management, and complications in children.

Subjects And Methods

Study setting and Study population
This is a quasi-experimental (pre-post interventional) study conducted at El Nasr hospitals, Port Said governorate, Egypt. Port Said Governorate is located in the north-eastern part of the country, on the Mediterranean Sea and at the northern gate of the Suez Canal. The approval of the Medical Ethical Committee of the Faculty of Medicine, Suez Canal University was obtained before commencing the study, and informed consent was obtained from every enrolled participant. All pediatricians working at El Nasr Hospital and regularly dealing with children presenting with DKA were subjected to enrollment. While medical interns training at El Nasr Hospital, pediatricians who wouldn't be available in the study setting during the whole duration of the study and pediatricians unwilling to participate were excluded. The study included 28 subjects.

Methods

We conducted this study in three phases; pre-intervention; focusing on assessing the baseline awareness through a pre-test, intervention; in which the health education program will be conducted, and post-intervention; focusing on assessing the impact of the program on improving pediatricians' awareness towards DKA by a post-test.

The pre-intervention phase
The questionnaire consisted of three sections; *section A* collected the personal data of the pediatricians, *section B* consisted of 22 items and addressed DKA diagnosis, monitoring, complications, and treatment, and finally, *section C* presented a DKA case scenario and evaluated pediatricians' management of the case through 6 questions.

The intervention phase
This includes a lecture and handouts.

Post-intervention phase
After the educational program, we contacted the pediatricians once again for them to fill in the same questionnaire twice; just after the program (1st post-test) and six weeks later (2nd post-test).

Results

Table 1 shows a summary of the demographic characteristics of the included pediatricians. The mean age of physicians was 33.11 ± 6.0.5 years and about two-thirds of them (67.9 %) were females. The percentage of them who had a master's degree is 35.7%, whereas only 7.1 % completed the Egyptian diploma. The mean duration of the experience

was 5.78±5.2 years. About 32.1 % of physicians reported that they refer DKA cases to governmental hospital while 35.7% reported that they refer cases to university hospital**.** Table 2 shows frequencies of questions answers related to diagnosis of DKA.

Table1. Demographic characteristics of pediatricians (n=28)	
Variables	**n (%)**
Age (yrs.), mean (SD)	33.11 (6.0.5)
Gender	
Male	9 (32.1)
Female	19 (67.9)
Post-graduation degree	
Diploma	2 (7.1)
Masters	10 (35.7)
Others	16 (57.1)
Duration of experience (yrs.), mean (SD)	5.78 (5.24)
Site of dealing with patients	
Refer to governmental Hospital	9 (32.1)
Refer to the University Hospital	10 (35.7)
In the same physician's Hospital	9 (32.1)

Data are presented as number (%) or mean (SD)

The percentage of physicians' answers on blood glucose level that should be in DKA ≥ 200 mg/dl is 28.5%, whereas the percentage in the first and second post-test assessment answers was ≥ 200 mg/dl (92.9 %) and (85.7%), respectively. The percentage of answers regarding the venous pH level in DKA in the pre-test, first, and second post-test assessment was <7.3 (89.3%), (92.9 %) and (85.7 %), respectively. The percentage of physicians who answered that urine ketones should be ≥2 at the pretest assessment is only (28.6%) which improved in the first post-test assessment to (89.3%) and the second post-test assessment to (75%). The percentage of physicians who answered that pH level and bicarbonate level is the determinant of severity of DKA is only (10.7%) in the pretest assessment improved in the first post-test assessment to (96.4%) and to (100%) in the second. Table 3 shows the frequencies of questions and answers related to the monitoring of DKA. The percentage of the physicians who answered that they should check vital signs every hour in the pretest is 41.4%. The percentage increased in the first post-test assessment to (96.4%) and in the second post-test assessment to (89.3%). Table 4 shows the frequencies of answers related to DKA treatment. The percentage of physicians who agreed that normal saline is the initial IV fluid you give for correction of DKA in the pretest is 78.6% and in the first, and second post-test reached 100%. The percentage of physicians that answered the maximum dose of initial IV fluid bolus fluid within the 1st hour of treatment is 20 ml/kg bolus is (64.3 %) in the pretest; however, most of them changed the answer to 30 ml/kg bolus in the first post-test assessment (92.9%) and second post-test assessment (64.3%). The percentage of physicians who respond that insulin should be delayed after the initiation of IV fluids is 75% in the pre-test,92.9% in the first post-test, and 100% in the second post-test.

The percentage of the respondents who answered that 0.1 units/kg/hour should be the initial dose of infused insulin that should be given to an infant in the pre-test assessment is 46.4%.

Table 2. Questions related to diagnosis of DKA

Questions	Pretest n (%)	Post-test1 n (%)	Post-test 2 n (%)
In DKA, blood glucose level should be:			
>150 mg/dl	2 (7.1)	0	0
*≥ 200 mg/dl	8 (28.5)	26 (92.9)	24 (85.7)
>250 mg/dl	5 (17.8)	2 (7.1)	3 (10.7)
> 300 mg/dl	13 (46.4)	0	1 (3.6)
In DKA, venous pH level should be			
*<7.3	23 (89.3)	26 (92.9)	24 (85.7)
>7.3	2 (7.1)	2 (7.1)	1 (3.6)
7.2 – 7.3	3 (10.7)	0	3 (10.7)
>7.4	0	0	0
Urine ketones are typically			
≥1	13 (46.4)	3 (10.7)	4 (14.3)
*≥2	8 (28.6)	25 (89.3)	21 (75)
≥3	7 (25)	0	3 (10.7)
≥4	0	0	0
The severity of DKA is determined by			
*The pH level, bicarbonate level	3 (10.7)	27 (96.4)	28 (100)
The pH level, bicarbonate level, and mental status	25 (89.3)	1 (3.6)	0
High glucose level	0	0	0

However, in the first and second post-test assessments most responses changed to 0.05 unit/kg/hour (100 %) and (89.3 %), respectively. The percentage of those who agreed that regular insulin should be the type of insulin used in infusion in the pretest assessment is 71.4%. Table 5 shows the frequencies of questions and answers related to DKA complication. Most responses in the pretest, first, and second post-test assessments agreed that cerebral edema is the most common cause of death in DKA patients (92.9 %), (92.9%) and (96.4%) respectively. The percentage of physicians in the pretest assessment answered that hypokalemia is the most common metabolic disorder while dealing with DKA patient is 57.1%. The frequency of this answer increased to 92.9% in the first post-test, however, answers decreased slightly to 71.4% in the second post-test assessment. The percentage of the respondents who see that giving hypertonic saline (3%) as a first choice is a wrong statement regarding managing of cerebral edema in DKA patients is 53.6%. The percentage increased to 100 % in the first post-test assessment and 82.1% in the second post-test assessment. Table 6 shows the frequencies of questions and answers related to DKA case management. Almost all physicians agreed at all assessments that the first step in the management of DKA is starting with shock therapy. In the pretest (35.7%) of the physicians see that the initial dose of infused insulin

given to that infant is 0.5 ml/h. In the first and second post-test assessments, almost all physicians agreed on this answer. Most physicians agreed that normal saline should be the type of fluid we will start with in this case in the pretest (89.3%), first (100%), and second (82.1%) post-test assessment.

Table 3. Questions related to DKA monitoring

Questions	Pretest n (%)	Post-test1 n (%)	Post-test 2 n (%)
Frequency of vital signs checking			
Every half hour	4 (14.3)	1 (3.6)	2 (7.1)
*Every hour	20 (41.4)	27 (96.4)	25 (89.3)
Every 2 hours	1 (3.6)	0	1 (3.6)
Every 3 hours	0	0	0
Frequency of electrolyte levels checking			
*Every 2 hours	8 (28.6)	28 (100)	23 (82.1)
Every 4 hours	11 (39.3)	0	5 (17.9)
Every 6 hours	7 (25)	0	0
Every 8 hours	0	0	0
Frequency of neurologic status assessment			
According to the patient condition	18 (64.3)	0	8 (28.6)
*Hourly	8 (28.6)	28 (100)	20 (71.4)
Every 4 hrs.	2 (7.1)	0	0
One of the following is not necessary in the management of DKA			
Potassium	0	0	0
Magnesium	3 (10.7)	0	4 (14.3)
Phosphate	5 (17.9)	0	1 (3.6)
*HbA1c	20 (71.4)	28 (100)	23 82.1)

There was comparable frequency in the responses regarding what to do if the serum k^+ is 5mEq/ml and the patient passed urine in the pretest assessment, however, almost all the physicians chose that they would start KCl as 40meq/l in all post-test assessments. Almost all physicians agreed at all assessments that if the patient's lab improves but is clinically still in bad general condition this is mostly because of cerebral edema. There was a comparable frequency in the responses regarding the total calculated IV fluid if no dehydration occurred, however, almost all physicians chose that it should be 1280 ml/24h in the first post-test assessment, and the ratio of this choice decreased slightly to 71.4% in the second post-test assessment. Table 7 shows that there were statistically significant differences among correct answers related to diagnosis of DKA at different time points in questions one ($p<0.001$), three ($p<0.001$), and four ($p<0.001$). Furthermore, pairwise tests were applied for the differences between various assessments showing that in question (1) there was a significant difference between the pretest assessment and the first

post-test assessment (p=0.001), and the pretest assessment and second post-test assessment (p=0.003). In question 3, there was a significant difference between the pretest assessment and the first post-test assessment (p<0.001) and the pretest assessment and the second post-test assessment (p<0.001).

Table 4. Questions related to DKA treatment			
Questions	**Pretest n (%)**	**Post-test1 n (%)**	**Post-test 2 n (%)**
What the initial IV fluid you give for correction of DKA			
Ringer lactate	3 (10.7)	0	0
*Normal saline	22 (78.6)	28 (100)	28 (100)
Glucose 5%	1 (3.6)	0	0
The maximum dose of initial IV fluid bolus fluid as shock therapy			
10ml/kg bolus	0	0	0
20ml/kg bolus	18 (64.3)	2 (7.1)	8 (28.6)
*30ml/kg bolus	8 (28.6)	26 (92.9)	18 (64.3)
No limit	1 (3.6)	0	0
Which of the following statement is true			
Insulin should be initiated rapidly in DKA.	0	2 (7.1)	0
*Insulin should be delayed after the initiation of IV fluids	21 (75)	26 (92.9)	28 (100)
Both should be given together at the same time.	6 (21.4)	0	0
What is the initial dose of infused insulin that should be given for an infant 2years or less			
0.1 unit/kg/hour	13 (46.4)	0	2 (7.1)
0.01 unit/kg/hour	3 (10.7)	0	0
0.5 unit/kg/hour	2 (7.1)	0	1 (3.6)
* 0.05 unit/kg/hour	9 (32.1)	28 (100)	25 (89.3)
What is the type of insulin used in infusion			
*Regular	20 (71.4)	28 (100)	27 (96.4)
Ultra-short	6 (21.4)	0	0
Long-acting	0	0	0
Dextrose IV is added when blood glucose level reach			
150mg/dl	1 (3.6)	0	0
200 mg/dl	6 (21.4)	0	0
*250 mg/dl	17 (60.7)	23 (82.1)	28 (100)
300mg /dl	3 (10.7)	5 (17.9)	0
When should insulin infusion cease			
Blood glucose within normal range	11 (39.3)	0	1 (3.6)
*pH >7.30, bicarbonate >15mmol	7 (25)	24 (85.7)	24 (85.7)
pH >7.30, bicarbonate <18mmol	2 (7.1)	0	0
pH =7.45, bicarbonate>18mmol	4 (14.3)	1 (3.6)	0
Potassium replacement therapy should be started			
*With the beginning of IV fluid	3 (10.7)	25 (89.3)	23 (82.1)
Give a shot before IV fluid.	2 (7.1)	3 (10.7)	2 (7.1)
Wait 6 hours after beginning of IV fluids	9 (21.1)	0	0
Start with insulin	10 (35.7)	0	2 (7.1)
While managing DKA, the K will be given in the following dose			
10mmol/l	1 (3.6)	0	1 (3.6)
20mmol/l	10 (35.7)	0	1 (3.6)
30mmol/l	0	2 (7.1)	5 (17.9)
*40mmol/l	10 (35.7)	23 (82.1)	20 (71.4)

Regarding question 4, there was a significant difference between the pretest assessment and the first post-test assessment (p<0.001), and the pretest assessment and the second post-test assessment (p<0.001). Otherwise, among all questions related to the diagnosis of DKA, there was no statistically significant difference between the second post-test assessment and first post-test.

Table 5. Questions related to DKA complications

Questions	Pretest n (%)	Post-test1 n (%)	Post-test 2 n (%)
What is the most common cause of death in DKA patients			
*Cerebral edema	26 (92.9)	26 (92.9)	27 (96.4)
Hypokalemia	1 (3.6)	1 (3.6)	0
Hyperkalemia	0	0	0
Hypernatremia	0	0	0
The most common metabolic disorder while dealing with DKA patient			
Hyperkalemia	6 (21.4)	1 (3.6)	2 (7.1)
*Hypokalemia	16 (57.1)	26 (92.9)	20 (71.4)
Hypernatremia	4 (14.3)	0	3 (10.7)
Hypocalcemia	0	0	0
Wrong statement regarding managing of cerebral edema in DKA pts			
Reduce rate of fluid administration by one-third.	8 (28.6)	0	4 (14.3)
Give mannitol as a first choice	4 (14.3)	0	1 (3.6)
*Give hypertonic saline (3%) as a first choice	15 (53.6)	28 (100)	23 (82.1)
Elevate the head 30 degree	0	0	0

Discussion

With the right treatment, diabetic ketoacidosis (DKA), a condition that poses a serious risk of death, can be effectively managed. One of the main objectives in the care of diabetes in children is to prevent DKA and its potentially fatal complications by raising awareness of the condition's early warning signs and constantly monitoring those who have it. Physicians should be knowledgeable about the immediate and efficient management of this condition to accomplish this goal and guarantee improved outcomes for DKA patients. The outcomes for diabetes patients can be improved by offering doctors an educational program that will increase their knowledge and confidence[8]. Our study included 28 pediatricians dealing with DKA patients to assess the baseline level of knowledge about DKA diagnosis, management, and complications as well as reassess these items after educating them about the recent ISPAD guidelines of DKA management, once after the health education, and the second after 6 weeks from it. After getting the baseline knowledge (pre-test) and the knowledge after reassessment (post-test), it was found that the knowledge of the physicians improved and increased significantly regarding DKA. This was obvious after comparing the results with each other, and the

summary of the positive results shows that there is a significant increase in the knowledge about the précised laboratory data important in diagnosing DKA, the important checkup and monitoring during treatment, DKA treatment with proper IV fluids and insulin administration, the complications of DKA and its treatment. Some of the previous studies investigated the role of training and educational programs on physicians' knowledge of DKA.

Table 6. Questions related to DKA case management

Questions	Pretest n (%)	Post-test 1 n (%)	Post-test 2 n (%)
The first step in the management of this case			
*Shock therapy	28 (100)	28 (100)	26 (92.9)
Maintenance and deficit fluid	0	0	2 (7.1)
Start insulin to improve the hyperglycemia	0	0	0
Bicarbonate for fear of profound acidosis	0	0	0
The initial dose of infused insulin given in that infant			
1 ml/h	7 (25)	0	3 (10.7)
10 ml/h	6 (21.4)	0	0
*0.5 ml/h	10 (35.7)	28 (100)0	26 (89.3)
5 ml/h	4 (14.3)	0	0
The type of fluid we will start with is			
Ringer	2 (7.1)	0	4 (14.3)
*Normal saline	25 (89.3)	28 (100)	23 (82.1)
Normal saline: D5	1 (3.6)	0	0
Panosol	0	0	0
If the serum k is 5mEq/ml, and the patient passed urine, which of the following statement is true:			
We will start KCl as 20meq/l	4 (14.3)	0	4 (14.3)
*We will start KCl as 40meq/l	9 (21.1)	28 (100)	21 (75)
We shouldn't start KCl as it is normal and to avoid hyperkalemia	4 (14.3)	0	3 (10.7)
KCl will be start as soon as the k level in blood decrease	7 (25)	0	0
The patient lab improves but clinically still bad general condition this is because			
Hypokalemia	3 (10.7)	1 (3.6)	3 (10.7)
Hypomagnesaemia	1 (3.6)	0	0
Hypernatremia	0	0	2 (7.1)
*Cerebral edema	23 (82.1)	27 (96.4)	23 (82.1)
In this infant, if no dehydration the total calculated IV fluid will be:			
700 ml/24h	4 (14.3)	0	0
780 ml/24h	6 (21.4)	2 (7.1)	8 (28.6)
*1280 ml/24h	5 (17.9)	26 (92.9)	20 (71.4)
Others	10 (35.7)	0	0

Correct answer

However, and to the best of our knowledge, this is the first study of its kind to evaluate such an impact based on ISPAD guidelines. Volkova et al (2008) investigated the value of a multidisciplinary educational intervention,

based on the American Diabetes Association (ADA) guidelines, in increasing doctors' compliance with DKA guidelines, and demonstrated a significant impact of this intervention. Moreover, Rajendran et al. found that providing an educational project for trainee doctors enhanced their knowledge and confidence and improved diabetic patients' outcomes[9]. For the initial bedside diagnosis, information from the clinical presentation can be helpful. Dehydration, tachycardia, tachypnea, shallow breathing, acetone breath odors, nausea, vomiting, stomach discomfort, blurred vision, disorientation, drowsiness, a steady decline in level of awareness, and eventually loss of consciousness are the prominent symptoms (coma).

Table 7: Correct answers related to the diagnosis of DKA at the different time points

Questions	Pretest n (%)	Post-test1 n (%)	Post-test 2 n (%)	p-value [a]
Q1. Average blood glucose in DKA	8 (28.6)	26 (92.9) [β]	24 (85.7) [β]	**<0.001***
Q2. In DKA, venous Ph level should be	23 (89.3)	26 (92.9)	24 (85.7)	0.76
Q3. Typical urine ketones in DKA	8 (28.6)	25 (89.3) [β]	21 (75) [β]	**<0.001***
Q4. Determined of DKA severity is	2 (7.1)	27 (96.4) [β]	28 (100) [β]	**<0.001***

*[a] P-value is based on Cochran's Q test. * Statistical significance at p < 0.05.*
Values with superscript [β] are different from the pretest group.

Despite the value of these presentations, test results are also crucial[10]. ISPAD guidelines in 2014 indicated that DKA diagnosis is established when the blood glucose level is > 200 mg/dL, the venous pH level is <7.3, ketonuria or serum BOHB value is >3 mmol/L. Moreover, DKA severity is determined based on the initial measurement of pH, pCO2, and bicarbonate levels [17]. The same was estimated in ISPAD guidelines in 2018 with adding urine ketones which are typically ≥2+ ("moderate or large") positive[11]. In our results, it was found that there was a statistically significant difference between the pre and post-test regarding how blood glucose levels should be and typical urine ketone levels while most of the physicians already knew that the Ph level should be <7.2. It was also found that their perception changed regarding the determination method of the severity of DKA as they responded in the pre-test that Ph level, bicarbonate level, and mental status are the determinants of severity of DKA though the true determinants were the Ph and bicarbonate level only showing significant difference between the two results. Similarly, when Mou et al. evaluated doctors' knowledge of DKA, they discovered that while 89% of them were aware that children with DKA had ketonuria, only 50% of them strongly agreed or agreed that these kids had a BOBH >3. The majority of doctors in our study were aware that the appropriate venous pH level in DKA was 7.3 before the program was implemented, therefore the difference in their knowledge between before and after the program was statistically negligible[19]. Similarly, Volkova et al reported that physicians had good compliance with arterial/venous blood gas evaluation in DKA patients which did not change significantly after the educational program[12]. ISPAD guidelines in both 2014 and 2018

recommended assessing vital signs every hour, electrolyte level every 2 hours, and neurological status every hour[13]. Meanwhile, Volkova et al reported that all physicians were already compliant with electrolyte monitoring before applying the program. However, they found that doctors' compliance with glucose monitoring increased significantly after the educational program. Furthermore, before the program, over 40% of our physicians knew that vital signs should be checked every hour, yet only 28% of them answered that neurological status should be assessed hourly[14].

Conclusion

The educational program has boosted the pediatricians' knowledge regarding DKA diagnosis, monitoring, complications, and treatment. Male pediatricians had better scores prior to the program compared to their female counterparts; however, the knowledge of all pediatricians was improved after the program regardless of their gender. Pediatricians' postgraduate degrees, age, and duration of experience after graduation were not significantly related to the degree of improvement in their knowledge following the educational program.

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