Original Article

Glycemic control in the infectious diseases ward; role of clinical pharmacist interventions

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Abstract

Introduction: Hyperglycemia is one of the most frequent metabolic complications in hospitalized patients. Increased risk of infection following hyperglycemia has been reported in hospitalized patients and infections may also cause insulin resistance which complicates the control of blood glucose level. In this study the impact of the clinical pharmacist interventions on the glycemic control in patients admitted to infectious diseases ward has been evaluated.

Methodology: We conducted a prospective, pre-post interventional study among patients with hyperglycemia. The clinical pharmacist-led multidisciplinary team managed the glycemic profile of patients according to an established insulin protocol commonly used in internal wards. Clinical pharmacists reviewed patients' medical charts for proper insulin administration, evaluated nurses' technique for insulin injection and blood glucose measurement, and educated patients about symptoms of hypoglycemia and the importance of adherence to different aspects of their glycemic management.

Results: The percentage of controlled random blood sugar increased from 13.8% in the pre-intervention to 22.3% in the post-intervention group (p value < 0.01). On the other hand, the percentage of controlled fasting blood sugars in the post-intervention group was non-significantly higher than in the pre-intervention group.

Conclusion: Pharmacists and additional health care providers from other departments such as nursing and dietary departments need to be devoted to glycemic control service. Collaborative practice agreement between physicians is necessary to promote this service and help to increase the use of such services in different settings for diabetes control.

Key words: Clinical pharmacy interventions; glycemic control; infectious diseases ward

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Introduction

Diabetes mellitus is one of the most important public health concerns worldwide [1, 2]. It has been estimated that patients with diabetes will be hospitalized two to five times more than those without diabetes [3]. The reported prevalence of hyperglycemia in hospitalized patients is different based on definition of hyperglycemia and study populations [4]. It ranges from 32% in community hospitals to 80% during the perioperative period in cardiac surgery subjects [5-8].

Hyperglycemia in hospitalized patients with different conditions such as critically ill patients, general medical-surgical care, cardiac surgery, acute myocardial infarction and infection is associated with adverse outcomes [9-11]. These negative consequences include longer hospital length of stay, increased hospital costs, higher rate of intensive care unit (ICU) admission, and higher hospital mortality rates [3]. Hyperglycemia management while avoiding hypoglycemia may mitigate most of these complications and has been associated with favorable outcomes [3].

The relationship between hyperglycemia and infection appears to be bidirectional and inter-dependent [2]. The presence of hyperglycemia has been demonstrated to be associated with an increased risk of infection in critically as well as non-critically ill patients [2, 4]. This might be the result of suppressing immune functions by hyperglycemia secondary to impaired phagocytosis, diminished production of oxygen radicals from neutrophils, and chemotaxis [12]. On the other hand, infection as a prominent stress condition has been known to be

associated with hyperglycemia through increased level of counter-regulatory hormones (e.g. cortisol, epinephrine, glucagon), activation of the inflammatory cascade, and oxidative stress [2, 4]. In this regards, infectious diseases especially pneumonia and urinary tract infections account for 20% to 55% of all precipitating causes of hyperglycemic crises [13].

The active involvement of pharmacists, especially clinical pharmacists, in the glycemic control of hospitalized patients has reduced the length of hospital stay, the rate of hyperglycemia, as well as hypoglycemic events [3]. In a pre-post, observational study in hospitalized surgical patients with perioperative dysglycemia, the implementation of a glycemic control protocol by a team of trained pharmacists has been associated with a statistically significant improvement in measures of glycemic control as well as with a decrease in the rate of hypoglycemic events in postoperative days [14]. Similarly, in a 3-year prospective survey at a 564-bed medical center in the United States, Warrington *et al* demonstrated that the development of a pharmacist-led, multidisciplinary diabetes management team contributes in achieving glycemic control (serum blood glucose concentrations less than 200 mg/dl) and decrease in the incidence of sternal surgical-site infections in patients undergoing the coronary artery bypass graft (CABG) procedure [15]. According to the American Diabetes Association (ADA) statement, a collaborative team including physicians, nurses, dietitians, pharmacists, and mental health professionals, is necessary to improve medical care of patients with diabetes [2].

Glycemic control carried out by pharmacists in hospitalized patients has been the subject of several studies published so far. However, to the best of our knowledge, clinical pharmacist activities in controlling dysglycemia have not been specifically assessed in non-critically ill patients with different infectious diseases. The main purpose of the current study was to evaluate the probable impacts of clinical pharmacists interventions on the profile of serum blood glucose in patients admitted to a referral center for infectious diseases.

Methodology

A prospective (pre-post) interventional study was conducted during two periods: the first between January 1, 2010 and July 31, 2011 (pre-intervention period) and the second between August 1, 2011 and November 31, 2012 (post-intervention period). The study setting was a 60-bed infectious diseases ward of Imam Khomeini hospital, a multispecialty health care university facility, affiliated to Tehran University of Medical Sciences, Tehran, Iran. The Institutional Review Board (IRB) and the Medical Ethics Committee of the hospital approved the study. The study is in accordance with 1975 Helsinki Declaration as revised in 1996.

Among patients admitted to the ward with diabetes mellitus or stress-induced hyperglycemia, those who needed blood glucose monitoring and management were included in our study. In the pre-intervention group, only patients with registered glycemic control monitoring form in their medical files were considered eligible for inclusion. The competent patients only received regular and NPH insulin rather than oral anti-diabetic agents for glycemic control during the stay in the infectious diseases ward. The diabetes control team consisted of clinical pharmacists (one attending and at least two residents rotated on a bi-monthly basis) working in collaboration with physicians (attendings and residents of infectious diseases), nurses, and dietitians. Physicians and clinical pharmacists simultaneously visited every patient at least once daily. Rounding clinical pharmacists in collaboration with physicians, optimally managed glycemic control by adjusting insulin dose in response to related clinical signs/symptoms and results of blood glucose measurement. In order to monitor insulin therapy, capillary blood glucose was measured daily at 4 time points within a day including fasting, (2-hours) after breakfast (post-prandial, PP), evening (PM), and bedtime (HS). If patients were non per oral, blood glucose was monitored every 4 or 6 hours depending on clinical conditions of patients. Results of blood glucose measurements were recorded in specific monitoring charts. Glycemic control was in accordance to an established insulin protocol commonly used in internal wards [16]. In addition, clinical pharmacists reviewed patients' medical records for prescribed insulin (type, dose, and time of administration), compared it with the insulin administered by nurses, and corrected any possible discrepancy between them. Besides, clinical pharmacists evaluated nurses' technique for insulin administration (appropriate type, dose, and time of administration) and blood glucose measurement by glucometer. Finally, clinical pharmacists educated patients about major symptoms of hypoglycemia and the importance of adherence to different aspects of their glycemic treatment especially for adherence to related medications and meal plans for better glycemic control. Interventions of clinical pharmacists for

glycemic control during this study are summarized in Table 1. Interventions including insulin, hypoglycemic and nutritional management were written in the chart of patients by clinical pharmacists. It should be mentioned that these interventions were also provided for pre-intervention group by health care providers except clinical pharmacists, but not in accordance with a specified and standard protocol. The principles of glycemic control during this study did not change in the literature [2].

According to a definition commonly used in medical wards, fasting and random blood glucose level should be less than 140 and 180 mg/dl, respectively [2, 16]. Hypoglycemia defines as fasting or random blood glucose level less than 70 mg/dl [2]. Required data including demographic characteristics (age, sex, underlying diseases), final diagnosis, length of stay at infectious diseases ward, glycemic profile (fasting, PP, PM, and HS blood glucose), and paraclinical findings (serum creatinine [SrCr], serum urea, white blood cell count [WBC], erythrocyte sedimentation rate [ESR], c-reactive protein [CRP], serum glutamic oxaloacetic transaminase [SGOT], serum glutamic pyruvic transaminase [SGPT], and serum alkaline phosphatase [ALP]) were extracted from patients' medical records. These data were filled into the specific questionnaire.

Statistical analysis

Continuous variables were expressed as mean ± SD and categorical data as percentage. The distribution of continuous variables was assessed by Kolmogrov-Smirnov test. The chi-square test was used to analyze categorical data between pre- and post-intervention groups. The association between glycemic control and continuous variables was assessed by independent sample *t* test for parametric and Mann-Whitney U test for non-parametric variables. The comparison of demographic, clinical, and paraclinical characteristics of patients with and without controlled fasting or random blood sugar was performed by multivariate logistic regression analysis to calculate odds ratios (ORs) and their 95% confidence intervals (CIs). P-values less than 0.05 were considered as statistically significant. Statistical analyses were done with SPSS version 11.5 software (SPSS Inc., Chicago, IL, USA).

Results

According to the inclusion criteria in the pre-intervention period, a total of 66 patients (between January 1, 2010 andJuly 31, 2011) were recruited. In the post intervention period (between August1, 2011and November 31, 2012), 139 patients were evaluated. Ninety seven percent versus 62.5% of patients in pre- and post-intervention groups had preadmission diagnosis of type 2 diabetes, respectively; the remaining patients in each group were diagnosed as affected by stress-induced hyperglycemia who needed insulin treatment for glycemic control. Demographic characteristics, final diagnosis, length of stay at infectious diseases ward, in-hospital clinical outcome, and laboratory findings of the study population is summarized in Table 2. Subjects (in the pre- and post- intervention groups) did not differ significantly for age, final diagnosis, in-hospital clinical outcome, ESR, serum SGOT and SGPT. In addition, the number of patients who received medications that could induce hyperglycemia such as corticosteroids, thiazide diuretics, nicotinic acid, beta blockers, HIV protease inhibitors, pentamidine, atypical antipsychotics, and oral contraceptives did not differ significantly between the two groups (p value > 0.05, data not shown).

The comparison of the mean fasting and random blood sugar values of patients in two groups is shown in Table 3. The mean random sugar values reported at 10 AM and 10 PM were significantly lower in the post-intervention than in the pre-intervention group (p value < 0.01 for both time points).

The percentage of controlled random blood glucoses at 10 AM and 10 PM in the post-intervention group (43.7% and 46.6%, respectively) were significantly higher than the values in the pre-intervention group (28.3% and 25.4%, respectively; p value = 0.04 at10 AM and blood glucose p value < 0.01 at10 PM). However, there were no statistically significant difference between the percentages of controlled fasting blood sugar (13.8% vs. 22.3%) and random blood sugar at 4 PM (20% vs. 20.2%) in pre- and post- intervention groups, respectively (p value = 0.12 and 0.57 for fasting blood sugar and random blood sugar measured at 4 PM, respectively). The overall percentage of controlled random blood sugar at all time points increased from 24.5% to 36.4% in pre- and post-intervention groups, respectively (p value < 0.01). The incidence of hypoglycemic episodes did not differ significantly between pre- and post-intervention groups (2.48% versus 2.64%, respectively; p value = 1). Regarding the outcome, most of the patients in both pre- and post-intervention groups (90.8% and 94.2%, respectively; p value = 0.39) were discharged from the hospital.

Table1. Different interventions of clinical pharmacists for glycemic control

Monitoring	Blood glucose at 4 time points within a day including fasting, (2-hour) after breakfast (post-prandial, PP), evening (PM), and bedtime (HS). If patients were non per oral, blood glucose was monitored every 4 or 6 hrs depending on clinical conditions of patients
Hold oral anti-diabetic medications (if necessary based on blood glucose and illness status)	
Insulin management	Starting insulin therapy (scheduled insulin) Basal and prandial insulin (NPH/regular) [2, 16]
Correction of daily insulin dose (based on BS monitoring)	Increase in daily insulin doses (regular and/or NPH) attributed to illness, stress, or treatment [16] Basal: Increase if fasting or PM blood glucose elevated persistently Prandial insulin: Increase if PP blood glucose elevated persistently
Supplemental insulin dose (if necessary)	This dose was used to supplement scheduled regular insulin (if patients had uncontrolled blood glucose)
Hypoglycemic management	Patient education[a] about major symptoms of hypoglycemia and hypoglycemic management based on ADA-guideline management [2]during hospsitalization and at discharge.
Nutritional status management	Eating Any dextrose-containing fluids were changed to non-dextrose-containing fluids Prolonged non per oral Continue dextrose containing fluid Patient education[a] about adherence to nutritional plan during hospitalization
Correcting medication error (about insulin)	Compared patients' medical records for ordered insulin (type, dose, and time of administration) with what administered by nurses and corrected any errors
Correcting any inaccuracy of nurses' technique for insulin administration (appropriate type, dose, and time of insulin administration) and blood glucose measurement by glucometer	
Patient education[a] at discharge	Importance of adherence to different aspects of their glycemic treatment especially adherence to related medications and meal plans for better glycemic control

BS monitoring: blood sugar monitoring, NPO: non per oral.
[a] Education was offered as verbal and pamphlet only by clinical pharmacists according to educational status of patients.

Table 2. Comparison of demographic data, diagnosis and laboratory results between pre intervention and post intervention group

Variables	Pre-intervention (n = 66)	Post-intervention (n = 139)	*P*
Sex (%)			
Male	26.2	59.6	<0.01
Female	73.8	40.4	
Age (years)			
Mean ± SD	58.06 ± 11.07	56.9 ± 17.29	0.08
Past medical history (underlying disease) (%)[a]			
Diabetes mellitus	45.5	36.7	<0.01
Cardiovascular disease	22.4	16	
Hyperlipidemia	15.7	6.8	
Renal disease	7.0	5.5	
No past medical history	0.7	24.1	
Others	11.7	10.9	
Final diagnosis (%)			
Skin & soft tissue infection	73.8	64.7	0.91
CNS infections	4.6	4.9	
Tuberculosis	4.6	4.9	
Urinary tract infections	5.9	3.1	
Gastrointestinal infections	3.1	2.9	
Other diagnosis	10.8	17.7	
Length of stay at infectious diseases ward (days)			
Mean ± SD	21.07±15.1	14.7±11.7	<0.01
In-hospital clinical outcome (%)			
Discharged	90.8	94.2	0.39
Inpatient	9.2	5.8	
White blood cell count (/mm^3)			
Mean ± SD	10182.9±4740.9	11348±5565.5	0.03
Erythrocyte sedimentation rate (mm/hr)			
Mean ± SD	80.6±34.5	70.2±39.1	0.09
C-reactive protein (mg/dl)			
Mean ± SD	16.6±19.5	44.9±28.8	<0.01
Serum creatinine (mg/dl)			
Mean ± SD	1.3±0.6	1.5±1.3	<0.01
Serum urea (mg/dl)			
Mean ± SD	42.5±17.4	50.7±33.9	<0.01
Serum SGOT (IU/l)			
Mean ± SD	28.6±46.1	29.2±23.3	0.24
Serum SGPT (IU/l)			
Mean ± SD	21.9±21.3	30.4±20.4	0.05
Serum alkhaline phosphatase (IU/l)			
Mean ± SD	246.9±134.8	404.44±339.9	<0.01

[a] The ratio of the number of a certain underlying disease to the total number of underlying diseases. Each patient might have more than 1 underlying disease.

Table 3. Comparison of the mean fasting and random blood sugar in pre-intervention and post-intervention group

	Variable	Pre-intervention	Post-intervention	P-value
Fasting blood sugar (mg/dl)	Mean ± SD	198.5±62.2	182.2±52.5	0.07
Blood sugar at 10 A.M. (mg/dl)	Mean ± SD	221.6±61.0	191.2±59.8	< 0.01
Blood sugar at 4 P.M. (mg/dl)	Mean ± SD	248.2±73.1	240.9±73.5	0.53
Blood sugar at 10 P.M. (mg/dl)	Mean ± SD	226.1±59.7	192.4±53.0	< 0.01

Table 4. Comparison of demographic, clinical, and paraclinical characteristics between patients with and without controlled fasting blood sugar

Variables	Controlled fasting blood sugar (n = 42)	Not controlled fasting blood sugar (n = 163)	OR (95% CI)	*P*
Sex				
Male (%)	22 (52.4)	72 (44.2)	1.048	0.96
Female (%)	20 (47.6)	91 (55.8)	(0.133-8.288)	
Age (years)				
Mean ± SD	56.9 ± 17.3	58.1 ± 11.1	0.953	0.17
Range	18-83	24-87	(0.889-1.022)	
Diagnosis				
Skin & soft tissue infection	17 (40.5)	122 (74.8)	4.202	0.18
Non-skin & soft tissue infection	25 (59.5)	41 (25.2)	(0.505-34.940)	
Number of co-morbidities				
Mean ± SD	1.7 ± 0.9	1.8 ± 0.9	0.944	0.92
Range	0-3	0-4	(0.296-3.004)	
Length of stay at infectious diseases ward (days)				
Mean ± SD	17.2 ± 11.6	17.2 ±14.0	1.018	0.56
Range	1-44	2-72	(0.958-1.082)	
White blood cell count (/mm^3)				
Mean ± SD	10091 ± 6006	11093 ± 5138	1.02	0.47
Range	900-28700	2200-30000	(0.881-1.097)	
Erythrocyte sedimentation rate (mm/hr)				
Mean ± SD	65.1 ± 37.3	77.4 ± 37.0	1.019	0.28
Range	10-131	5-143	(0.985-1.054)	
C-reactive protein (mg/dl)				
Mean ± SD	39.9 ± 29.7	38.8 ± 29.6	0.994	0.72
Range	0-90	0-101	(0.964-1.026)	
Serum creatinine (mg/dl)				
Mean ± SD	1.3 ± 0.8	1.4 ± 1.2	1.019	0.97
Range	0.4-4.6	0.5-8.2	(0.362-2.87)	
Serum urea (mg/dl)				
Mean ± SD	48.0 ± 27.3	47.8 ± 29.4	1.026	0.19
Range	11.33-136	16.0-175.3	(0.987-1.065)	
Serum SGOT (IU/l)				
Mean ± SD	41.5 ± 32.7	23.1 ± 15.1	1.037	0.44
Range	13-157	2-81	(0.945-1.139)	
Serum SGPT (IU/l)				
Mean ± SD	41.3 ± 39.2	25.2 ± 21.9	1.028	0.55
Range	6-199	4-299	(0.939-1.125)	
Serum alkhaline phosphatase (IU/l)				
Mean ± SD	284.8 ± 166.2	346.0 ± 301.9	0.996	0.18
Range	130-943	85-2436	(0.991-1.002)	

Table 5. Comparison of demographic, clinical, and paraclinical characteristics between patients with and without controlled random blood sugar

Variables	Controlled random blood sugar (n = 42)	Not controlled random blood sugar (n = 163)	OR (95% CI)	*P*
Sex				
Male (%)	27 (64.3)	71 (43.6)	0.5	0.44
Female (%)	15 (35.7)	92 (56.4)	(0.085-2.956)	
Age (years)				
Mean ± SD	56.1 ± 15.3	58.2 ± 11.7	0.951	0.16
Range	21-83	18-87	(0.886-1.020)	
Diagnosis				
Skin & soft tissue infection	20 (47.6)	118 (72.4)	2.251	0.40
Non-skin & soft tissue infection	22 (52.4)	45 (27.6)	(0.335-15.119)	
Number of co-morbidities				
Mean ± SD	1.7 ± 1.0	1.8 ± 0.9	1.013	1.0
Range	0-3	0-4	(0.41-2.506)	
Length of stay at infectious diseases ward (days)				
Mean ± SD	20.8 ± 16.7	16.3 ± 12.5	1.034	0.18
Range	2-72	1-60	(0.985-1.085)	
White blood cell count (/mm^3)				
Mean ± SD	10455 ± 6193	11002 ± 5074	1.07	0.47
Range	900-28700	3000-30000	(0.91-1.067)	
Erythrocyte sedimentation rate (mm/hr)				
Mean ± SD	67.8 ± 35.1	76.4 ±38.2	0.996	0.78
Range	17-131	5-143	(0.971-1.023)	
C-reactive protein (mg/dl)				
Mean ± SD	44.0 ± 28.7	37.9 ± 29.7	1.012	0.42
Range	4.5-95	2-101	(0.983-1.042)	
Serum creatinine (mg/dl)				
Mean ± SD	1.5 ± 1.2	1.4 ±1.1	0.65	0.42
Range	0.4-5.1	0.5-8.2	(0.228-1.85)	
Serum urea (mg/dl)				
Mean ± SD	49.6 ± 35.4	47.2 ± 27.2	1.035	0.09
Range	11.3-164.0	16.0-175.0	(0.994-1.077)	
Serum SGOT (IU/l)				
Mean ± SD	35.6 ± 31.2	24.7 ± 16.1	0.929	0.17
Range	10.0-157.0	2.0-81.0	(0.836-1.032)	
Serum SGPT (IU/l)				
Mean ± SD	33.4 ± 31.8	26.6 ± 22.9	1.097	0.08
Range	6.0-120.0	4.0-299.0	(0.988-1.217)	
Serum alkhaline phosphatase (IU/l)				
Mean ± SD	290.6 ± 162.0	346.4 ± 305.0	0.999	0.53
Range	131.0-943.0	85.0-2436.0	(0.995-1.003)	

Tables 4 and 5 summarize the results of multivariate logistic regression comparing demographic, clinical, and paraclinical characteristics between patients with and without controlled fasting or random blood sugar. No significant risk factor for uncontrolled fasting or random blood sugar was detected in the study population.

Discussion

Thanks to the evolution of clinical pharmacy in Iran and the increased cooperation of clinical pharmacists in multidisciplinary team, they have played a beneficial role in implementing new services to address various problems in different clinical settings such as infectious diseases wards [17-19]. Controlling blood glucose is difficult in hospitalized patients especially among those with infectious diseases [20]. However, with this study, clinical pharmacists for the first time adopted a multidisciplinary approach to optimize inpatient glucose control specifically in an infectious diseases ward.

Several studies supported the favorable effect of pharmacist-led, multidisciplinary team in managing diabetes in different settings [3, 14, 15]. Mularski *et al*. in a pre-post observational study published in 2012 evaluated the role of a pharmacist-led glycemic control team in managing hyperglycemia in surgical patients with perioperative dysglycemia (diabetes or stress hyperglycemia). They found that 77.4% of postoperative patient-days of patients demonstrated good glycemic control in the pre-intervention group. This increased to 90.3% in the post-intervention period. In addition, during the pharmacist intervention, the rate of hypoglycemia decreased from 8.6% to 4.6%. They concluded that safer as well as higher quality standard in glycemic care were achieved involving a pharmacist team in the management of hyperglycemia in hospitalized, postoperative patients [14]. The ADA also suggested that the collaborative and integrated team approach to medical care of patients with diabetes is essential to provide adequate diabetes management and development of various aspects for glycemic control [2]. In a similar manner, according to the result of our study, a clinical pharmacist-led multidisciplinary approach to diabetes management has been shown to improve glycemic control. This might partially account for significantly shorter duration of hospitalization in the post-intervention group. We reported 8.5% increase (from 13.8% to 22.3%) in the rate of controlled fasting blood sugar and 11.9% increase (from 24.5% to 36.4%) in the rate of controlled random blood sugar after the clinical pharmacist interventions. On the other hand, although we could not decrease the incidence of hypoglycemia, the rate of hypoglycemic episodes was comparable between pre- and post-intervention groups (2.64% versus 2.48 %, respectively).

We did not detect any demographic, clinical, and paraclinical characteristics of patients as risk factors for uncontrolled blood glucose. In contrast to our findings, Jeon *et al*. demonstrated that persistently high glucose level could be an indication of underlying undiagnosed infection. They also reported that glucose levels ≥ 110 mg/dl during two days of infection were associated with blood stream infections (OR from 2.04 to 2.67), and glucose levels ≥ 180 mg/dl were associated with pneumonia (OR = 2.30) [11].Since all patients in our study were diagnosed with infectious diseases, performing such analysis was not feasible. However, we detected no statistically significant association between different diagnosis of infectious diseases and glycemic control (p value = 0.18 for fasting and p value = 0.4 for random blood sugar). Khattaba *et al*. also evaluated factors associated with poor glycemic control among outpatients with type 2 diabetes in Jordan [21]. Although many factors such as the increased duration of diabetes, non-compliance with the nutrition plan recommended by dietitians, negative thoughts towards diabetes, and increased barriers to adherence scale scores were significantly related to poor glycemic control in their survey, but these appear to have no concern for our hospitalized cohort [22].

All (100%) of our interventions in glycemic control were accepted by the health-care team in the current survey. We reported an acceptance rate of 80% and 100% in previous studies [17]. In addition, from the same clinical settings we recently reported that the highest satisfaction rates of nursing staff on clinical pharmacist services were related to education on the proper preparation method, storage, and administration of drugs and regular presence in the ward [23]. These findings suggest a good professional relationship between clinical pharmacists and other health care provider teams and a favorable perception and acceptance of their activities.

Some limitations exist in this study and cautions must be taken when interpreting the results. The type of underlying diseases, gender, some laboratory results (WBC, CRP, SrCr, ALP, and serum urea) and the reason for insulin administration (type 2 diabetes versus stress-induced hyperglycemia) were significantly different between pre- and post-intervention groups and they can be considered as confounding factors. Regarding the last item, more patients in the pre-intervention than in the post-intervention group had preadmission diagnosis of type 2 diabetes (97% versus 62.5%, respectively). Insulin non-responsiveness and resistance may be more common in patients with type 2 diabetes than stress induced hyperglycemia. Therefore, the reason for

insulin administration may partially affect the rate of glycemic control in our study population. It is also possible that there were unmeasured confounders associated with glycemic control such as stress-causing procedures (surgery) not considered in this study. Additionally, our study was limited because we did not access to data about the exact doses of insulin injected for each patient in the pre-intervention group. Therefore, comparing the total daily insulin dose administered between two groups was not possible. Because of short mean duration of hospitalization among the study population (twenty versus fourteen days in the pre- and post-intervention groups, respectively), we did not measure HbA1c as a favorable criteria of glycemic control that reflects the average blood glucose levels over the previous three months [24]. Moreover, assessing the accuracy of the technique and the time of glucose monitoring as a potential confounding factors for uncontrolled glucose was not feasible since these data were not recorded in the medical chart of patients in the pre-intervention group. Lastly, because the primary endpoint of the study was the impact of clinical pharmacist interventions on the glycemic control of patients, plausible effects of these interventions on cost and long-term survival of our cohort were not considered. However, our recently published study indicated that clinical pharmacist interventions non-significantly decreased the total direct medication cost of patients in the same clinical setting [23]. Additional larger, multi-centered, well-designed studies are needed to evaluate the real clinical outcome and cost-effectiveness of glycemic control by clinical pharmacists' activities in patients with various infectious diseases.

Conclusion

The result of the current study suggested that active participation of clinical pharmacists in health-care team may be effective and safe for glycemic control in patients with various infectious diseases. So, clinical pharmacists and additional health care providers from other departments (e.g., nursing and dietary) need to be devoted to this service to manage diabetes in hospitalized patients effectively and safely. A collaborative practice agreement between physicians is necessary to promote this service and help to increase the use of such services for diabetes control in different clinical settings.

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