Relationship between Postoperative Infectious Complications and Glycemic Control for Diabetic Patients in an Orthopedic Hospital in Kuwait

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Key Words

Diabetes mellitus · Hemoglobin A_{1c} · Postoperative infectious complications · Glycemic control

Abstract

Objective: To study the relationship between postoperative infectious complications and glycemic control for diabetic patients in an orthopedic hospital in Kuwait. **Subjects and Methods:** Patients who underwent surgical orthopedic procedures between 2006 and 2007 were identified to provide demographic and clinical informations including age, gender, type of surgery, length of operation, HbA_{1c} values, nature of specimens and species of the isolated pathogens. HbA_{1c} <7% was used as the breaking point for diabetic control and occurrence of postoperative complications. Primary outcomes with infectious complications, including urinary tract infection, surgical site infection (SSI), lower respiratory tract infection and sepsis with different isolated pathogens were identified at least 48 h postoperatively. **Results:** Of 318 diabetic patients who underwent surgical operations, 90 (28.3%) developed postoperative complications; HbA_{1c} <7% was significantly associated with decreased infectious complications with an adjusted odds ratio of 2.51 (95% confidence interval, 1.20–2.89). Regarding types of complications, urinary tract infectious complications were significantly higher among those patients with HbA_{1c} ≥7% ($p < 0.0001$), while other complications (SSI, lower respiratory tract infec-

tion and sepsis) showed nonsignificant differences ($p > 0.05$).

Conclusions: Our study confirmed a close association between preoperative glucose control indicated by HbA_{1c} levels <7% and a decreased risk of postoperative infectious complications. Ideally, preoperative blood sugar should be controlled prior to elective surgery. Prophylaxis by antibiotics with preoperative patient preparation, proficient surgical technique and postoperative wound care is recommended for uncontrolled diabetics subjected to surgery.

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Introduction

Diabetes mellitus (DM) is a serious public health problem and remains an important cause of morbidity and mortality worldwide [1]. In Kuwait 1996–1998, the overall prevalence of glucose intolerance and non-insulin-dependent DM was 7 and 15.7%, respectively [2]. As DM alters the metabolism of blood sugar, patients with DM are at risk of numerous complications related to microangiopathies and neuropathies [3]. Postoperative infectious complications lead to prolonged hospitalization, poor overall outcomes and high health care costs, particularly for patients with DM for whom the risk of infection is greater and the outcome is worse [4], as reported in a variety of orthopedic procedures [5]. Di Palo et al. [6] demonstrated that diabetic patients had a considerably

higher rate of septic complications in clean surgical procedures. Wimmer et al. [7] analyzed 850 patients who underwent spinal procedures and argued that DM was a predisposing factor for infection in spinal surgery. Again, Simpson et al. [8] compared 62 diabetic patients who had posterior decompression surgery with 62 age- and sex-matched nondiabetic patients who had undergone similar procedures. There were high rates of postoperative infection, prolonged hospitalization and poorer postoperative results among the diabetic patients [8].

HbA_{1c} reflects ambient mean glycemia over the previous 2–3 months. Reports indicate that patients with an elevated HbA_{1c} have an increased risk of adverse outcomes following surgical intervention (infection, stroke, adverse cardiac events and mean length of hospital stay) [9]. For diabetic patients, tight control, as measured by percent HbA_{1c}, has greatly decreased the incidence and severity of many chronic complications associated directly with diabetes such as nephropathy, neuropathy and retinopathy [10–12].

This study was conducted to determine whether proper preoperative glucose control indicated by HbA_{1c} levels <7% was associated with fewer postoperative infections in diabetic patients undergoing a variety of orthopedic surgical procedures.

Subjects and Methods

Study Design and Data Collection

This retrospective observational study was carried out in the Departments of Clinical Chemistry and Medical Microbiology, Al Razi Hospital, Kuwait, one of the major orthopedic hospitals with 210 beds. Diabetic patients who underwent surgical orthopedic procedures in Al Razi Hospital from January 2006 to December 2007 were identified from the patients' medical records (laboratory request forms, log books and patient files). These forms provided demographic and clinical information on patients including age, gender, relevant clinical data, HbA_{1c} values, type of specimen and data from microbiological reports, including species of the isolated pathogen. In addition, clinical data, type of surgery, length of operation and information on postoperative complications were obtained from the patients' files.

Patient Selection

Patients included in our study had established DM (regardless of diabetes subtype) and had received antidiabetic treatment for at least 1 year before surgery. The presence of DM before hospital admission was documented in the admission note, emergency room note, admission orders and discharge summary or by prescription of antidiabetic medications in the admission orders. Patients recently diagnosed as having DM, impaired glucose tolerance or who were already on antibiotics were excluded from the study.

Laboratory Data

HbA_{1c} levels recorded within 1 month prior to surgery were used in the study. The degree of glycemic control was assessed by HbA_{1c} values more or less than 7% [13]. HbA_{1c} was determined immunoturbidimetrically using Cobas Integra 400 Plus [14].

For microbiological data, patients were classified as having a postoperative infection if any of the following infections developed after 48 h or later: surgical site infection (SSI), lower respiratory tract infection, urinary tract infection (UTI) or sepsis [15]. Patients' specimens (urine, pus or tissue, sputum, blood) were collected and cultured. The representative colonies were identified using the automated Vitek ID system (Bio-Mérieux Vitek Inc., Hazelwood, Mo., USA) and APIE20 (Bio-Mérieux Inc., Marcy l'Etoile, France). These tests were made and criteria for the results were assessed according to the manufacturer's instructions. In addition, *Staphylococcus* species isolates were identified by Gram's stain and the tube coagulation test.

Outcome Measures

All measures were defined according to Center for Disease Control and Prevention guidelines based on clinical and laboratory findings [15]. The measures were followed while the patient was in hospital after 48 h or later, or within 30 days after surgery with purulent drainage at the site of incision.

Statistical Analysis

All data management and analysis were done using SPSS version 15 [16]. The descriptive statistics, including frequencies, were used to describe the study findings. The association between two discrete variables was tested by χ^2 analysis; $p < 0.05$ was considered significant. Logistic regression was also used, including the factors that were statistically significant at $p < 0.05$ in the unadjusted analyses to produce adjusted results showing the independent impact of each factor on the outcome. Odds ratios and their corresponding confidence intervals and p values were also calculated.

Results

Study Population and Patient Characteristics

During the study period, a total of 318 diabetic patients were assessed. Patients were predominantly male (175, 55.0%) with a median age of 58 years (range: 6–60); the median operative duration was 120 min. The range of recorded HbA_{1c} levels was 4.9–15.5% with a median level of 8.5%. The majority of surgical operations were peripheral musculoskeletal (192; 60.4%). Ninety (28.3%) patients developed postoperative infectious complications (table 1).

Postoperative Infectious Complications

The distribution of total postoperative infectious complications according to a breaking point of HbA_{1c} <7% versus $\geq 7\%$ is listed in table 2. There is a significant relationship between the occurrence of complications and

a high level of HbA_{1c} ($p < 0.05$). Of the 90 patients who developed complications, 72 developed 1 type and the remaining 18 developed 2 types, making a total of 108 postoperative complications.

The distribution of postoperative infectious complications according to a breaking point of HbA_{1c} $<7\%$ versus $\geq 7\%$ is listed in table 3. Urinary tract infectious complications showed a highly significant difference between the two HbA_{1c} groups ($p < 0.0001$), while differences for the other complications (SSI, lower respiratory tract infection or sepsis) were not significant ($p > 0.05$).

Bacterial Isolates

One hundred and eight specimens were subjected to bacteriological cultures yielding 140 bacterial isolates. Of the 108 specimens, 78 (72.22%) had single isolates while 30 (27.77%) had mixed isolates. The numbers of all types of isolated organisms were higher in the group with HbA_{1c} $\geq 7\%$. The distributions of uropathogens and pathogens isolated from patients with SSI are shown in table 4A and B, respectively. Among the 60 urinary specimens, *Escherichia coli* (27%) was the most predominant pathogen followed by *Klebsiella pneumoniae* (20%), *Pseudomonas aeruginosa* (13%) and *Enterococcus faecalis* (12%). Of the 60 inpatients with SSI, the most commonly isolated organisms were *Staphylococcus aureus* (23%), *Staphylococcus epidermidis* (20%), *P. aeruginosa* (12%) and *Enterobacter cloacae* (10%).

Preoperative Variables and Postoperative Infectious Complications

The percentages of patients with infectious complications according to sociodemographic characteristics of the study populations are listed in table 5. Factors associated with higher infectious risk included: HbA_{1c}, age and open type of surgery ($p < 0.05$), whereas sex, nationality and operation length had no significant impact on out-

come. The significant variables in the unadjusted analysis were then entered into a multiple logistic regression model.

In this analysis, the type of operation was not a significant risk factor for postoperative infection, whereas age (odds ratio, 1.03; 95% confidence interval, 1.02–1.08) and HbA_{1c} levels (odds ratio, 2.51; 95% confidence interval, 1.20–2.89) continued to be significant.

Table 1. Sociodemographic characteristics of the studied population (n = 318)

Variable	Number (%)
Sex	
Male	175 (55.0)
Female	143 (45.0)
Nationality	
Kuwaiti	170 (53.5)
Non-Kuwaiti	148 (46.5)
Type of surgery	
Open	29 (9.1)
Closed	
Spine	40 (12.6)
Pelvic	20 (6.3)
Arthroplasty	37 (11.6)
Peripheral musculoskeletal	192 (60.4)
Operation length	
<120 min	139 (43.7)
≥ 120 min	179 (56.3)
HbA _{1c}	
Median, %	8.5 (NA)
Range, %	4.9–15.5 (NA)
$<7\%$	80 (25.2)
$\geq 7\%$	238 (74.8)
Postoperative complications	
Absent	228 (71.7)
Present	90 (28.3)
NA = Not applicable.	

Table 2. Distribution of studied patients according to level of HbA_{1c} and postoperative complications

Postoperative complications	Patients with HbA _{1c} $<7\%$ (n = 80)		Patients with HbA _{1c} $\geq 7\%$ (n = 238)		Total patients (n = 318)		p value
	n	%	n	%	n	%	
Absent	66	82.5	162	68.10	228	71.70	<0.01
Present	14	17.5	76	31.9	90	28.30	
One complication	10	12.5	62	26.0	72	22.64	>0.05
Two complications	4	5.0	14	5.9	18	5.66	

Table 3. Distribution of types of postoperative complications according to glycemic control of the operated patients

Type of infections	Total	HbA _{1c} <7%		HbA _{1c} ≥7%		p value
		n	%	n	%	
UTI						
Absent	272	76	27.94	196	72.06	<0.0001
Present	46	4	8.7	42	91.30	
SSI						
Absent	275	70	25.45	205	74.55	>0.05
Present	43	10	23.26	33	76.74	
LRTI						
Absent	303	78	25.74	225	74.26	>0.05
Present	15	2	13.33	13	86.67	
Sepsis						
Absent	314	78	24.84	236	75.16	>0.05
Present	4	2	50.00	2	50.00	

LRTI = Lower respiratory tract infection.

Table 4A. Prevalence of predominant uropathogen isolated from urine of post-operative patients

Organisms	Total (n = 60)	HbA _{1c} %	
		<7	≥7
<i>Escherchia coli</i>	16 (27%)	1	15
<i>Klebsiella pneumoniae</i>	12 (20%)	2	10
<i>Pseudomonas aeruginosa</i>	8 (13%)	0	8
<i>Enterococcus faecalis</i>	7 (12%)	0	7
Others	17 (28%)	1	16

Table 4B. Prevalence of predominant pathogen isolated from SSI of post-operative patients

Organisms	Total (n = 60)	HbA _{1c} %	
		<7	≥7
<i>Staphylococcus aureus</i>	14 (23%)	5	9
<i>Staphylococcus epidermidis</i>	12 (20%)	2	10
<i>Pseudomonas aeruginosa</i>	7 (12%)	2	5
<i>Enterobacter cloacea</i>	6 (10%)	0	6
Others	21 (35%)	2	19

Discussion

Using the American Diabetes Association target for HbA_{1c} levels of less than 7% to define good glycemic control [13], our data showed that good preoperative glyce-

Table 5. Preoperative variables and postoperative infectious complications

Variable	All patients (n = 318)	Percent with infections	p value
Age			
<58 years	158	22.8	<0.03
>58 years	160	33.8	
Sex			
Male	175	28.0	>0.05
Female	143	28.7	
Nationality			
Kuwaiti	170	28.2	>0.05
Non-Kuwaiti	148	28.4	
Type of surgery			
Open	29	55.2	<0.002
Closed			
Spine	40	27.5	
Pelvic	20	25.0	
Arthroplasty	37	45.9	
Peripheral musculoskeletal	192	21.4	
Operation length			
<120 min	139	23	>0.05
≥120 min	179	32.4	
HbA _{1c}			
<7%	80	17.5	<0.01
≥7%	238	31.9	

mic control leads to a significantly lower risk of postoperative infections.

Wilson et al. [17] and Bishop et al. [18] had explored the question of whether or not long-term control of blood glucose affected the occurrence of postoperative infections. Each of these had been limited to the study of SSI in a group of patients undergoing a specific type of operation [17, 18]. Our selected patients underwent a variety of orthopedic surgical procedures and were evaluated for all potential infectious complications, not just SSI.

There was a very significantly lower risk of postoperative infection in the well-controlled diabetic group (HbA_{1c} <7%) compared to the uncontrolled group (HbA_{1c} ≥7%) regarding the occurrence of UTI (p < 0.01). Our data confirmed the previous study reported by Dronge et al. [19].

Regarding UTI, our data showed a significantly higher percentage of postoperative UTI in patients with uncontrolled diabetes compared to those with controlled diabetes (p < 0.01). Yang et al. [20] studied 86 diabetic patients who underwent total knee arthroplasty; 15% developed UTI within 1 month postoperatively. Unfortu-

nately, they did not examine the relationship between UTI and $HbA_{1c} \geq 7\%$ [20].

Regarding the occurrence of postoperative pneumonia and sepsis, our data showed no significant difference between controlled and uncontrolled diabetic subjects ($p > 0.05$). This may be due to the low number of subjects with these complications in our study, resulting in low statistical power. Further study examining larger numbers of patients with these complications is recommended.

No significant difference for the occurrence of SSI was found between our two postoperative groups ($p > 0.05$), similar to the previous findings of Wilson et al. [17], who reported no association between $HbA_{1c} \geq 11.5\%$ and SSI. However, our data were not in agreement with those of Bishop et al. [18], who used a cutoff level of $HbA_{1c} > 11.5\%$, thereby placing all diabetic patients with HbA_{1c} between 7 and 11.5% in the well-controlled group, which is not consistent with present recommendations of the American Diabetes Association [13].

Glycemic control is a risk factor for the occurrence of postoperative infection in diabetics, but other factors must also be considered, including smoking, body mass index, alcohol abuse, immune status of the patient, steroid therapy, nutrition status, type of operation (elective or emergency), duration of operation, number of medical personnel during operation, estimated blood loss, use of allograft or instrumentation, drainage and its duration and American Society of Anesthesiologists preoperative assessment score [21, 22].

This study has highlighted two microbiological issues. First, that *S. aureus* remains the most important microorganism responsible for postoperative wound infection in our orthopedic hospital, accounting for 23%, thereby confirming a previous study [23]. Secondly, *E. coli* continues to be the most common uropathogen of UTI (27%), as this finding also confirmed that of a previous study in Kuwait that examined both hospital- and community-acquired UTI [24] and those of Drongue et al. [19].

There are two primary complications for diabetic patients: macrovascular and microvascular diseases. Plaques easily form in the circulatory system of patients with macrovascular disease, producing a high carriage rate of organisms. In patients with microangiopathy, subsequent decreased nutrition and oxygen delivery to peripheral tissues can reduce the body's ability to resist infection [25]. Poor blood sugar control will impair the leukocytic ability for chemotaxis [26, 27], adherence [28], phagocytosis and intracellular elimination of microorganisms [29].

Neither chronic complications nor the type of diabetes therapy was examined in the study. The Diabetes Control and Complications Trial Research Group proved that intensively monitored insulin therapy reduces the risk of retinopathy, albuminuria, microalbuminuria and neuropathy when compared to conventional therapy in type I diabetes [30]. Again, the United Kingdom Prospective Diabetes Study showed that patients with type 2 DM who received intensive glucose therapy had a lower risk of microvascular complications than did those receiving conventional dietary therapy [31]. Other factors that are known to be associated with postoperative infection were not included in the study, i.e. wound classification, urgency of cases, smoking, nutritional status and blood loss.

Conclusion

Our study confirmed an association between tight preoperative glucose control indicated by HbA_{1c} levels less than 7% and a decreased risk of postoperative infections. Ideally, preoperative blood sugar should be controlled by conservative treatment prior to elective surgery. If conservative treatment fails and surgery is indicated, prophylaxis by antibiotics with preoperative patient preparation, proficient surgical technique and postoperative wound care is recommended for uncontrolled diabetics subjected to urgent surgery.

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