Prevalence of Diabetes Mellitus in the Surgical Population of the University of Puerto Rico Affiliated Hospitals: A Study using the Surgery Database

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Objective: To evaluate the prevalence of diabetes mellitus in the surgical population of the University of Puerto Rico (UPR)-affiliated hospitals.

Methods: We examined all the surgical cases that were entered into the Surgical Database from April 1, 2014 through September 30, 2014. This database collects patient and procedural information from different surgical services of various UPR-affiliated hospitals (the University District Hospital, the University Pediatric Hospital, the UPR Carolina Hospital, the Dr. Isaac Gonzalez Oncologic Hospital, the PR Cardiovascular Center [thoracic service], the Pavia Hospital [colorectal service], and the Auxilio Mutuo Hospital [colorectal and oncological services]). The prevalence of diabetes mellitus (types 1 and 2 combined) was estimated, and the nondiabetic and diabetic groups were compared. The difference between groups was evaluated using a Chi2 test, Student's t-test, or ANOVA, whichever was appropriate, with a p-value of less than 0.05 being considered significant.

Results: Information from 2,603 surgical patients was available. The mean age of the group was 49 (±23) years. The gender distribution indicated that 56% were women and 44% were men. Diabetes was present in 21% of the surgical population, increasing to 40% in patients aged 65 and over. The surgical procedures most frequently required by diabetic patients were in the categories of general surgery (36%), colorectal surgery (22%), vascular surgery (16%) and oncologic surgery (14%). Complications (5%, diabetic group vs. 2%, nondiabetic group; p<0.05) and postoperative mortality (2%, diabetic group vs. 0.2%, nondiabetic group; p<0.05) were significantly higher in the diabetic group than in the nondiabetic group.

Conclusion: Our surgical population has a high prevalence of diabetes, and these diabetic patients showed higher complication and mortality rates from surgery than did the non-diabetic patients. Surgeons must consider the specific needs of these diabetic patients in order to provide optimal care.

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Key words: Diabetes mellitus, Surgery, Comorbidity

The global prevalence of diabetes mellitus in adults aged 18 years and over, as reported by the World Health Organization, is 9% (1). The overall prevalence in the United States is currently 9%, and, in comparison, Puerto Ricans have a reported prevalence of 15% (1–3). Diabetes mellitus is reported as the third leading cause of death in Puerto Rico (4).

Diabetic patients have high rates of infection and cardiovascular complications following surgery (5–8). For example, large scale studies analyzing the information in the National Surgical Quality Improvement Program database have reported that patients with diabetes and no significant comorbidities have a higher risk of developing surgical site infection after an appendectomy (9) or a mastectomy (10) than do their nondiabetic counterparts. It has also been reported that diabetes mellitus, independent of insulin use, is associated with an increased risk of cardiac complications after vascular surgery (11). It is therefore important for surgeons to have a reliable estimate of the prevalence of diabetes in the surgical population they serve.

The aim of this study was to evaluate the prevalence of diabetes mellitus in the surgical-patient population of several University of Puerto Rico (UPR)-affiliated hospitals. The study also compared the diabetic and nondiabetic groups in

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terms of the surgical services used and the outcomes of the procedures performed.

Information for this study was obtained from the Surgery Database of the Department of Surgery of UPR.

Methods

We examined all the surgical cases from April 1, 2014 through September 30, 2014, in the Surgery Database. Compliant with the Health Insurance Portability and Accountability Act (HIPAA), this database of surgical procedures is both secure and confidential. The database compiles (by case) the basic demographic information and clinical and surgical data of each patient recorded therein. It collects information from the surgical services of several of the UPR-affiliated hospitals (the University District Hospital, the University Pediatric Hospital, the UPR Carolina Hospital, the Dr. Isaac González Oncologic Hospital, the PR Cardiovascular Center [thoracic service], the Pavia Hospital [colorectal service] and the Auxilio Mutuo Hospital [colorectal and oncologic services]). The data are obtained from the regular weekly reports produced by the residents of the various surgical services at the participating hospitals. The data aggregation is then compiled from the existing data that resulted from those surgical procedures that were performed on patients at the affiliated institutions. Personal identifiers are not included in the aggregated data. The database includes the following variables: a given patient's age and gender, the surgical service that provided care to said patient, outpatient/inpatient status, the patient's diagnosis (or diagnoses, if such should be the case), the international classification of disease (ICD) code(s) that applied to the patient's condition or conditions, the surgical procedure(s) performed, the current procedural terminology (CPT) code(s) of the procedure(s) performed, whether the procedure(s) in question was/were elective or emergent in nature, the wound classification(s), the patient's body mass index (BMI), the American Society of Anesthesiologists (ASA) physical status classification, whether or not the patient had diabetes, and the surgical outcome. This database uses the history provided by each patient as the criteria for classifying that patient as diabetic (or not, as the case may be). For the purpose of the database, outcomes were categorized as being uneventful or as resulting in minor morbidity, major morbidity, or mortality. In the database, the term minor morbidity is used when there is a superficial wound infection, superficial wound disruption, small seroma, small hematoma, or postoperative ileus; major morbidity is used when the outcome includes any postoperative complication that requires medical/surgical attention and that is not included in the minor morbidity category.

The prevalence of diabetes mellitus (types 1 and 2 combined) was estimated and the nondiabetic and diabetic groups were compared. The surgical outcomes of the 2 groups were evaluated by age group (<65 vs. ≥65 years) and gender. The BMIs of the patients and the percentages of overweight and obesity were compared between the diabetic and nondiabetic groups. This study used the National Institute of Health (NIH) classification, which defines overweight as a BMI ranging from 25.0 to 29.9 and obesity as a BMI of 30 or above (12).

Statistical analyses were performed with the software program SPSS, version 22.0 (Chicago, Illinois). Quantitative variables were expressed as means plus or minus standard deviations. Categorical variables were presented as frequencies and percentages. Student's t-test and analysis of variance (ANOVA) were used to compare quantitative variables between the groups. Differences between proportions were compared using the Chi-squared test. Results were considered significant when the p-value was less than 0.05.

This database was reviewed and approved by the Institutional Review Board (IRB) of the University of Puerto Rico Medical Sciences Campus.

Results

During the 6-month period of our study, the Surgery Database collected information on 2,603 surgical cases. The mean age of the group was 49 (±23) years. The gender distribution indicated that 56% were women and 44% were men. Diabetes mellitus was present in 21% of the surgical population, showing an increasing prevalence with age (Figure 1). In patients aged 65 years and over, the prevalence of diabetes was 40%.

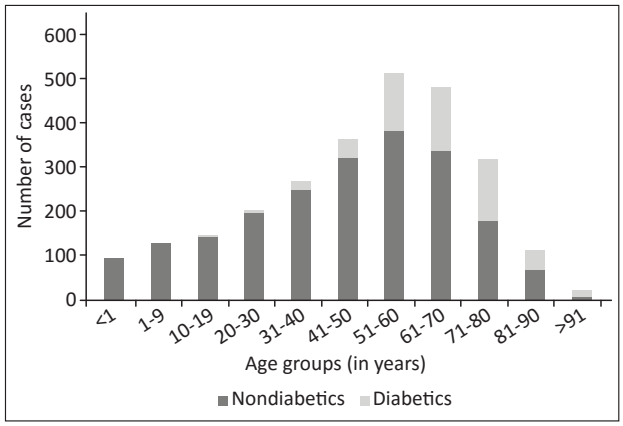

Figure 1. Distribution of diabetes in the surgical patients, by age group.

The surgical services required most frequently by diabetic patients were in the categories of general surgery (36%), colorectal surgery (22%), vascular surgery (16%), and oncologic surgery (14%) (Table 1). Since amputations are a frequent problem of diabetic patients (13), this particular group of general surgical procedures was evaluated in a manner independent from that of the other general surgical procedures (Table 2). The study found that 48 (96%) of the 50 lower-extremity amputations performed by the general surgery service during the 6-month study period were performed on diabetic patients. Lower-extremity amputations

Table 1. The variables evaluated and the comparisons between nondiabetic and diabetic groups.

Variables n = 2,603	Frequency n (%)	Age (years) mean ± SD	*P* value[A]	Nondiabetic* n = 2040 (79%)	Diabetic* n = 534 (21%)	*P* value[B]
*Gender**						
Male	1136 (44%)	46.7 ± 23.8	<0.05	892 (44%)	229 (43%)	<0.05
Female	1461 (56%)	50.7 ± 21.4		1149 (56%)	303 (57%)	
*Surgery Service**						
Cardiothoracic	48 (2%)	41.8 ± 23.8	<0.05	35 (2%)	13 (2%)	<0.05
Colorectal	680 (26%)	54.9 ± 16.5		553 (27%)	119 (22%)	
General	768 (30%)	48.6 ± 19.6		573 (28%)	194 (36%)	
Oncologic	503 (19%)	58.9 ± 14.7		425 (21%)	76 (14%)	
Pediatric	273 (10%)	5.8 ± 5.7		271 (13%)		
Plastic	67 (3%)	46.0 ± 15.3		58 (3%)	6 (1%)	
Vascular	112 (4%)	66.9 ± 13.6		28 (1%)	84 (16%)	
Hepatobiliary	152 (6%)	57.5±16.1		97 (5%)	42 (8%)	
*Admission Status**						
Inpatient	1582 (61%)	46.9 ± 24.6	<0.05	1170 (57%)	391 (73%)	<0.05
Outpatient	1018 (39%)	52.0 ± 18.7		868 (43%)	143 (27%)	
*Wound Classification**						
Clean	1214 (47%)	46.9 ± 24.6	<0.05	974 (46%)	232 (43%)	<0.05
Clean-contaminated	980 (38%)	52.0 ± 18.7		790 (39%)	184 (35%)	
Contaminated	138 (5%)	46.9 ± 24.6		95 (5%)	43 (8%)	
Dirty/infected	158 (6%)	52.0 ± 18.7		99 (5%)	59 (11%)	
Other	40 (1%)	46.9 ± 24.6		35 (2%)	5 (1%)	
N/A	73 (3%)	52.0 ± 18.7				
*Outcome**						
Uneventful	2491 (96%)	48.7 ± 22.6	<0.05	1989 (98%)	490 (93%)	<0.05
Minor morbidity	42 (2%)	58.7 ± 20.4		23 (1%)	19 (4%)	
Major morbidity	19 (1%)	46.7 ± 28.3		13 (1%)	6 (1%)	
Mortality	16 (1%)	66.3 ± 15.8		5 (0.2%)	11 (2%)	
*Surgery Type**						
Elective	2202 (85%)	50.0 ± 22.1	<0.05	1749 (86%)	441 (83%)	<0.05
Emergency	366 (14%)	42.3 ± 24.7		281 (14%)	85 (16%)	
ASA Physical Status Classification						
1 -normal	872 (35%)	38.6 ± 22.7	<0.05	829 (41%)	43 (8%)	<0.05
2 -mild systemic	1259 (49%)	52.2 ± 20.1		1026 (51%)	233 (44%)	
3 -severe systemic	353 (14%)	59.9 ± 22.2		148 (7%)	205 (39%)	
4 -life threatening	60 (2%)	63.6 ± 16.7		18 (1%)	42 (8%)	
5 -moribund	3 (0.1%)	53.7 ± 21.4		1 (0.0%)	2 (0.4%)	

[A]Student's t-test or ANOVA for p-value. [B]Chi-squared test for p-value. *Comparisons for some of the surgeries were not recorded.

Table 2. Amputation cases done by general surgery, codified according to the current procedural terminology (CPT) code.

CPT	Procedure (amputation type)	Frequency n (%)	Nondiabetics n (%)	Diabetics n (%)	*P-value*
27590	Above knee	11 (22%)	0 (0%)	11 (22%)	<0.05
27880	Below knee	14 (28%)	1 (2%)	13 (26%)	
28805	Metatarsal	2 (4%)	0 (0%)	2 (4%)	
28810	Metatarsal with toe	7 (14%)	1 (2%)	6 (12%)	
28820	Toe	16 (32%)	0 (0%)	16 (32%)	
Total n		50 (100%)	2 (4%)	48 (96%)	

Chi-squared test used for p-value.

accounted for 9% of all the surgeries performed on diabetic patients. We also found that the vascular surgery service had the highest percentage of diabetic patients; in this service an overwhelming 75% of the patients (84 of 112) had a diagnosis of diabetes mellitus.

Diabetic patients tend to more frequently require hospitalization for their surgeries (73% vs. 57%), so the percentage of inpatient procedures was significantly higher ($p<0.05$). A higher percentage of surgical wounds in diabetics were classified as contaminated (8%, diabetics, vs. 5%, nondiabetics) or dirty/infected (11%, diabetics, vs. 5%, nondiabetics), a difference that was statistically significant ($p<0.05$) (Table 1).

Complications (minor and major morbidity combined) were reported in 5% of the diabetic cases, and postoperative mortality was reported in 2% of those cases. Out of 16 reported mortalities during the 6-month period, 11 (69%) occurred in diabetic patients. Emergency surgery was required by 16% of the diabetic patients. The differences between the diabetic and the nondiabetic groups were significant in all the variables studied (Table 1).

The comparison by age group (<65 vs. ≥65 years) and gender is presented in Table 3. In general, the complication rates and mortality tended to be higher in the presence of diabetes, reaching statistical significance in both age groups and when women were compared (Table 3).

The mean BMI of the diabetic patients was higher than that of the nondiabetic patients (28.7 ± 6.9 kg/m^2 and 27.1 ± 7.7 kg/m^2, respectively); the percentages of obesity were similarly higher for the first compared to the second group (37% vs. 24%) (Table 4).

Of the 2,603 surgical cases, 61% were from public hospitals and 39% were from private hospitals. The prevalence of diabetes in public hospitals was 23%, and in private hospitals, it was 17% (Table 5).

Discussion

The overall prevalence of diabetes mellitus in our surgical population was 21%, which number increased with the age of the patients. This finding is in agreement with the prevalence of 25% of diabetes mellitus in admissions to the University Hospital reported in 2014 (14). It is also known that the prevalence of diabetes mellitus increases with age (2), which is consistent with our finding.

Table 3. Postoperative mortality and morbidity in nondiabetic vs. diabetic patients, by age group and gender.

Outcome	Age Group n (%)			Age Group n (%)		
	Nondiabetic <65 years	Diabetic <65 years	*P* Value	Nondiabetic ≥65 years	Diabetic ≥65 years	*P* Value
Mortality	2 (0.1%)	3 (1.2%)	< 0.05	3 (0.7%)	8 (2.9%)	<0.05
Major morbidity	12 (0.7%)	2 (0.8%)		1 (0.2%)	4 (1.4%)	
Minor morbidity	13 (0.8%)	7 (2.9%)		10 (2.4%)	12 (4.3%)	
Uneventful	1580 (98.3%)	232 (95.1%)		400 (96.6%)	256 (91.4%)	
Outcome	**Gender n (%)**			**Gender n (%)**		
	Nondiabetic Male	Diabetic Male	*P* Value	Nondiabetic Female	Diabetic Female	*P* Value
Mortality	2 (0.2%)	1 (0.4%)	0.19	3 (0.3%)	10 (3.4%)	<0.05
Major morbidity	10 (1.1%)	2 (0.9%)		3 (0.3%)	4 (1.3%)	
Minor morbidity	15 (1.7%)	9 (4.0%)		8 (0.7%)	10 (3.4%)	
Uneventful	859 (97.0%)	215 (94.7%)		1130 (98.8%)	273 (91.9%)	

Chi-squared test used for p-value.

Table 4. BMI, overweight, and obesity in the nondiabetic vs. diabetic groups

	Total	Nondiabetic	Diabetic	*P** value
Body Mass Index (kg/m^2)	27.5 ± 7.6	27.1 ± 7.7	28.7 ± 6.9	<0.05
Overweight (n, %)	1036 (44%)	826 (45%)	206 (40%)	0.03
Obese (n, %)	628 (27%)	432 (24%)	194 (37%)	<0.05

*Student's t-test for p-value for BMI and chi-squared test for p-value for overweight and obesity.

Table 5. Comparison of the proportion of subjects who were from public vs. private hospitals

	Public Hospitals n (%) 1591 (61%)	Private Hospitals n (%) 1012 (39%)	*P** value
Diabetic	326 (23%)	169 (17%)	<0.05

*Chi-squared test used for p-value.

Regarding the gender distribution of the surgical population, it was found to be similar to the distribution of the general population: 56% were female and 44% were male (15). The diabetic group had a larger number of women, 57%. The overall diabetes prevalence is higher in men (than in women), but more women than men have diabetes. The combined effect of a greater number of elderly women than elderly men in most populations and the increase of the prevalence of diabetes with age is the most likely explanation for this observation (18-20).

Peripheral arterial disease and lower-extremity amputations are both very frequent in diabetics (18–20). Therefore, we are not surprised to find that diabetics comprise 75% of the vascular surgical population of our sample and that 96% of the amputations in the general surgery service are performed on diabetics.

In general, patients with diabetes mellitus tend to have more associated medical problems than do their nondiabetic counterparts when they present for surgery (21). The need to manage such problems often requires hospitalization, which corresponds in our study to a higher percentage (73%, diabetics, vs. 57%, nondiabetics) of inpatient surgery. Diabetic patients also tend to be sicker when they present for surgery, as indicated by a significantly higher ASA classification (per each patient) and a higher percentage of wounds that are contaminated or dirty/infected at the time of surgery.

Surgical complications and mortality have both been reported to be higher in diabetic than in nondiabetic patients (22–24). In our study, complications (minor and major morbidities combined) were reported in 5% of diabetics but in only 2% of nondiabetics. Postoperative mortality was 2% for diabetic cases but only 0.2% for nondiabetics. The differences were statistically significant ($p<0.05$) for both complications and mortality between the 2 groups.

Among the factors that have been reported to be associated with an increased risk of death from diabetes mellitus are being a man and having diabetes for a long time (25). The evaluation of our outcomes by age indicated that the older diabetic patients had significantly higher surgical morbidity (5.7%) and mortality rates (2.9%) than did the younger ones (3.7% and 1.2%, respectively). In our study men with diabetes did not have a higher surgical mortality than men without diabetes did (0.4% vs. 0.2%; $p = 0.19$). A possible explanation for this finding is that the men in this study were significantly younger than the women (mean ages 47 and 51, respectively; $p<0.05$). The diabetic women had significantly higher complication (4.7% vs. 1.0%) and mortality rates (3.4% vs. 0.3%) than did the nondiabetic women.

Diabetic patients in our surgical population had higher BMIs (28.7±6.9) than the nondiabetic group did (27.1±7.7). Obesity (IBM≥30) was noted in 37% of the diabetic patients but in only 24% of the nondiabetics. It has been reported that obese patients have a higher frequency of diabetes than non-obese patients have (26), which is similar to what was found by our study.

Among the limitations of this study, it should be noted, is the fact that the Surgery Database does not distinguish between type 1 and type 2 diabetes mellitus. It has been reported that type 1 diabetes, usually diagnosed when the patient is a child or a young adult, accounts for about 5% of cases, while type 2 diabetes, usually diagnosed when the patient is an adult, accounts for 95% of the cases (27). The fact that, for this study, diabetic patients were identified via the history that those same patients provided and not through the verified presence of hyperglycemia (a hallmark sign of diabetes and which shows up on preoperative laboratory tests) must be considered a limitation of the study, since nearly 28% of people with diabetes are undiagnosed (28–29).

Another limitation of this study is that it grouped patients from public and private hospitals together when these 2

populations are not, in fact, that similar; for example the prevalence of diabetes was higher in the public hospitals than it was in the private ones (23% vs. 17%). In addition, the patients in the public hospitals probably had more limited access to preventive medical care and may have been receiving treatment somewhat later in the course of their disease.

It should also be noted that our database obtains information from UPR-affiliated hospitals and from several services of the participating private hospitals; the database does not, however, comprehensively encompass our general population, and it does not include patients who underwent cardiovascular surgery. Nonetheless, this study suggests that diabetic patients are an important percentage of the surgical workload, and we should be prepared to provide them with optimal health care management.

Conclusion

There was a high prevalence of diabetes in our surgical population; diabetic patients had significantly higher complication and mortality rates after surgery than did nondiabetic patients. It is therefore important for surgeons to have a reliable estimate of the prevalence of diabetes in the surgical population they serve so that they will be better able to develop strategies that meet the needs of these diabetic patients.

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