The effects of hyperglycemia on length of stay with myocardial infarction

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Abstract:

The influence of patients' co-morbidities and admission blood glucose on critical care and hospital length of stay was examined. The model significantly explained variance in hospital length of stay.

Keywords: hyperglycemia | diabetes | nursing | blood glucose | critical care | hospitalization | length of hospital stay | critical care nursing

Article:

Diabetes affects 18.2 million people in the United States and is responsible for $132 billion in health care spending per year, with $92 billion attributable to direct medical costs (Centers for Disease Control and Prevention [CDC], 2002). Approximately 75% of hospital admissions for individuals with diabetes are related to cardiovascular disease (Levetan, 2000). However, as many as 50% of those with diabetes, or approximately 8 million people, are underdiagnosed (The Expert Committee on the Diagnosis and Classification of Diabetes Mellitus [Expert Committee], 2003). Persons with hyperglycemia post-myocardial infarction (MI) (regardless of the formal diagnosis of diabetes) have an increased incidence of congestive heart failure, left ventricular failure, conduction abnormalities, and cardiogenic shock (Capes, Hunt, Malmberg, & Gerstein, 2000; Chyun, Vaccarino, Murrilo, Young, & Krumholz, 2002; Sala et al., 2002; Viejo, Chyun, Obata, Kling, & Tocchi, 2000; Wahab et al., 2002; Walker, 1999). These associated outcomes may contribute to an increased hospital length of stay (LOS).

Poor outcomes after MI in patients with hyperglycemia may be related to the physiologic effects of increased glucose on the myocardium. Hyperglycemia is associated with lack of insulin or resistance to insulin which leads to decreased glycolytic substrate for the myocardium and excess free fatty acids (McNulty, 2002). These chemical changes may promote decreased myocardial contractility, which leads to pump failure and promotes dysrhythmias. Hyperglycemia also promotes dehydration, thus decreasing intravascular volume; decreases the immune response; and causes electrolyte imbalances that may increase morbidity (Ahmann, 1998). One cause of

hyperglycemia with MI may be the stress response. The stress response results in increased cortisol and subsequent gluconeogenesis, thus increasing blood glucose levels (Guyton, 1981; Malmberg et al., 1995). A systematic review examining stress hyperglycemia after MI in persons with and without diabetes concluded that stress hyperglycemia led to increased risk of congestive heart failure or cardiogenic shock in patients without a formal diagnosis of diabetes (Capes et al., 2000).

Recently, the Expert Committee (2003) changed the criteria for hyperglycemia from greater than or equal to 140 milligrams per deciliter (mg/dl) to greater than 125 mg/dl. Although several studies have examined the outcome of mortality in MI patients with diabetes (Chyun et al., 2002; Ishihara et al., 2001; Malmberg et al., 1995), no studies have examined LOS in relation to hyperglycemia in an MI population. Therefore, the purposes of this study were to examine the proportion of patients admitted with an MI who did not have a formal diagnosis of diabetes, but had two or more elevated fasting blood glucose levels (using both the institutional standard of greater than 150 mg/dl and the new glucose standards), and to explore the relationship of admission blood glucose levels to LOS in the critical care unit and the hospital while controlling for the risk factors of obesity, smoking, and hypertension.

Methods

A randomized retrospective chart audit was used to answer the research questions.

Population and sample. Data collection occurred at a 529-bed urban hospital in the southeast region of the United States. This acute care facility is a major referral center for cardiovascular disease in the surrounding area. The sample included adults over the age of 21 who were discharged alive January 1 thru December 31, 2002, with a diagnosis of a first or subsequent MI as noted on the medical record (ICD9 code 410.0 to 410.9). Those who underwent coronary artery bypass grafting were excluded due to the extraneous effects of surgery on blood glucose.

A computer-generated randomized list of 213 patients meeting the inclusion criteria and their medical record numbers was created by the medical records department. Eighty-nine records were excluded because the medical records were not available (n=36), clients had undergone coronary artery bypass grafting (n=39), the medical record contained insufficient data, such as no health history form (n=13) to determine if the patient had a medical diagnosis of diabetes prior to

admission, or the patient left against medical advice (n=1). A total of 124 medical records were used for this study; 124 records have an 80% power to detect a [R.sup.2] of 0.10 (p [less than or equal to] 0.05) with five variables (Elashoff, 2000).

Instruments. A data collection instrument, the Myocardial Infarction and Glycemic Control (MGC), was used for this study. The MGC was created from the literature and through collaboration with diabetes clinical nurse specialists, registered nurses, and endocrinologists from the participating urban hospital. The development occurred in stages. Through the literature review, the researcher identified key areas and data needed to meet the study's purpose and answer the research questions. Then a subgroup, including both clinical nurse specialists in the area of diabetes and certified diabetes educators, was created. The purpose and research questions for the study were presented, and a preliminary audit tool was created collaboratively. The preliminary tool then was mailed electronically to all participants in the subgroup and the medical directors of the diabetes program. After suggestions were made, the tool was revised and presented to the diabetes medical directors for evaluation. The MGC then was modified based on this input and final revisions made. Content validity was obtained through the literature, collaborative construction of the tool, and in consultation with experts in the areas of diabetes, hyperglycemia, and cardiovascular disease. Each area of the tool provides data necessary to answer the research questions.

Data collection. The MGC was converted into an Access tool to allow data to be collected and entered directly in the computer. This procedure decreased potential errors by eliminating the need to collect data on a paper and pencil tool and then enter that data to a computer program. Each medical record was assigned an identification number. All data were collected in the medical records department. The data on the access file were then converted to a statistical file using SPSS 11.5 (2002).

Results

The age of the sample ranged from 33 to 92 years and averaged 62.2 (SD=14.57). The sample was divided into those with a medical diagnosis of diabetes on the medical record (n=40) and those without diabetes (n=84). Those with a formal diagnosis of diabetes on the medical record were older (see Table 1), more of them were hypertensive or obese (see Table 2), and had a greater proportion of women compared to those without a formal diagnosis of diabetes. The proportion of various races was similar in both groups.

Sixteen percent (n=20) of those in the sample had no admission blood glucose reported. The average admission blood glucose was 213 mg/dl (SD=152) for patients with diabetes and 99 mg/dl (SD=59) for those without diabetes.

Length of stay. Of those without diabetes in the sample, 71% (n=60) were admitted to a critical care unit during their hospitalization for acute MI; 52% (n=21) of those with diabetes were admitted to a critical care unit during their hospitalization. The average LOS for the entire sample (N=124) was 5.56 days (SD=3.7), with an average of 2.16 days (SD=2.59) spent in the CCU. The average hospital LOS for patients without diabetes was 4.9 days (SD=3.3) compared to 7 days (SD=4.2) for those with diabetes.

Research Question 1: What proportion of patients discharged with a diagnosis of an MI in 1 calendar year had two fasting blood glucose levels greater than 150 mg/dl, or greater than 125 mg/dl without previous medical diagnosis of diabetes? After excluding the admission blood glucose, 2% (n=2) of the sample without diabetes had two or more fasting blood glucose levels (FBG) greater than 150 mg/dl; 19% (n=16) had at least one FBG greater than 150 mg/dl. Under the new standards, 16% (n=14) experienced two or more FBG levels greater than 125 mg/dl.

Research Question 2: When controlling for co-morbidities (obesity, smoking, and hypertension), do admission blood glucose levels influence LOS in the CCU? When selecting patients with an admission blood glucose and CCU admission, a total of 65 subjects were included in this analysis. Multiple regression was used to answer this research question. To meet the assumptions of multiple regression, all variables were examined for normal distribution. Admission blood glucose was transformed using square root, and the days in CCU were transformed using logarithm. Body mass index (BMI) was removed from the model. Both hypertension and smoking were "dummy coded" (0=no and l=yes) and not tested for assumptions of multiple regression. Hypertension and smoking were entered into the first block (Model 1) to control for influence on CCU days. Admission blood glucose was then entered into the second block (Model 2). Neither Model 1 nor Model 2 showed a significant influence on CCU days ($F=0.345$ (3, 61); $p=0.793$).

Research Question 3. When controlling for co-morbidities (obesity, smoking, and hypertension), do admission blood glucose levels influence entire LOS? Multiple regression also was used to answer this research question about those with an admission blood glucose (n=104). To meet the assumptions of multiple regression, all variables were examined for normal distribution, and admission blood glucose and LOS were both transformed using square root. Again, BMI had no linearity and was removed from the model. Both hypertension and smoking were "dummy coded" (0=no and 1=yes) and not tested for assumptions of multiple regression. Hypertension and smoking were entered into the first block (Model 1) to control their influence on LOS. Admission blood glucose was then entered into the second block (Model 2). Model 1

significantly influenced LOS (F=4.709 (2,101); p=0.011). The total model significantly explained 9.8% of the variance in LOS (F=3.638 (3,100); p=0.015) (see Table 3). The only significant variable contributing to LOS in the final model was hypertension (B=0.265, t=2.728, p<0.01).

Discussion

According to the American Heart Association [AHA] (2003), the average age for a first MI is 65.8 years for men and 70.4 years for women. The mean age for the sample in the current study was somewhat younger than the AHA statistics but comprised similar proportions of males and females as those having MIs (AHA, 2003). The proportion of participants with a confirmed diagnosis of diabetes was similar to the proportion in the MI sample in the study by Sala et al. (2002). This high percentage of subjects with diabetes may be related to the fact that diabetics are at increased risk for coronary artery disease (Mukamal et al., 2001).

Over half of the sample in this study exceeded the recommended normal body mass index (BMI), and 61% of those with diabetes had BMIs above the normal range. A greater proportion (13.2%) of the sample with diabetes had extreme obesity (BMI [greater than or equal to] 40) compared to those without diabetes. The percentage of those above the normal BMI was slightly higher in the non-diabetic group which may be due to the difference in the size of the two samples. However, these findings are similar to the National Health and Nutrition Examination Survey indicating that up to 64.9% of the age-adjusted population has a BMI greater than 25 kg/[m.sup.2] (Flegal, Carroll, Ogden, & Johnson, 2002).

In this study, the majority of subjects without history of diabetes had BMIs greater than 25 kg/[m.sup.2]; of those, over 80% were 45 years of age or older. Because over 10% of the sample without diabetes had an admission blood glucose greater than 150 mg/dl, and over 16% (n=84) had two or more fasting blood glucoses greater than 125 mg/dl after MI, the sample of those without a confirmed diagnosis of diabetes may have in reality had pre-diabetes or diabetes. This emphasizes the need for screening for pre-diabetes in the MI population possibly to prevent or delay the onset of type II diabetes, decrease the risks of cardiovascular disease, and more importantly, prevent a subsequent MI. Further studies on the relationship of pre-diabetes on MI occurrence are needed.

The physiologic framework for this study purports that control of blood glucose with the MI population should decrease complications, and thus LOS (Malmberg et al., 1995). In this study, LOS after MI was longer for those clients with diabetes than those without diabetes (7 days vs. 4.9 days), thus supporting the physiologic framework. No other studies were found comparing LOS with glucose levels after MI. The increased LOS observed in the sample with diabetes indicates a need for additional research to determine effective interventions, such as a continuous insulin infusion, to change this statistic.

Because the stress response associated with an MI results in increased glucose levels (Guyton, 1981; Malmberg et al., 1995), the researchers assumed that more of the sample without diabetes may have had increased blood glucoses after MI than was found in this study. Based on the recommendation that two FBGs greater than 125 mg/dl indicate a diagnosis of type II diabetes (Expert Committee, 2003), 150 mg/dl may have been too high as the blood glucose cut-off level to screen adequately those MI patients without diabetes. While patients without diabetes had two or more FBGs greater than 125 mg/dl, it is difficult to determine if these two FBG were related to type II diabetes or the stress response. Prudent attention to the blood glucose in all patients who experience an MI provides the opportunity to identify and begin treatment to counter complications related to hyperglycemia. Further research to determine the level of blood glucose that significantly affects hospital LOS and outcomes is warranted. This information may assist nurses in creating and subsequently testing protocols to identify and treat hyperglycemia earlier.

Hypertension was present in a vast majority (92.5%) of the sample (n=40) who had diabetes. These results were higher than the CDC's (2004) report of 63% of persons with diabetes having hypertension. This high percentage may be related to extraneous effects of both hypertension and diabetes on the cardiovascular system with MI clients. When hypertension coexists with diabetes, the risk for cardiovascular disease doubles (Grundy et al., 1999). Therefore, those patients with hypertension may have had increased myocardial damage or prolonged recovery. Because this study had no measures of myocardial damage, more research should be done to investigate the effects of myocardial damage and hypertension on hospital LOS after MI in those with and without diabetes.

Hypertension was the only significant predictor of hospital LOS. Interestingly, hypertension was only weakly correlated with LOS in individuals without diabetes. Examining the role of hypertension and LOS in patients with and without diabetes may assist in designing interventions that can affect LOS. Decreasing the LOS by 1 day would have major financial implications; the average hospital cost per day for an MI is $6,790.37 (Agency for Healthcare Research and Quality, n.d.).

Krinsley (2004) found a significant decrease in intensive care unit LOS ($p=0.01$) and in hospital mortality ($p=0.002$) when maintaining plasma glucose levels less than 140 mg/dl. Similarly, Van den Berghe et al. (2001) found that the maintenance of blood glucose between 80 and 110 mg/dl using an insulin infusion decreased overall hospital mortality, bloodstream infections, renal failure, and blood transfusion, and decreased mechanical ventilation when compared to use of an insulin infusion for blood glucose greater than 215 mg/dl. Through decreasing these poor outcomes, LOS also may have been decreased. Continuous IV insulin was used only twice in the current study, each use being indicated for blood glucose greater than 400 mg/dl. Because this study could not determine whether continuous blood glucose control would affect outcomes such as LOS, further research is warranted.

Replication of this study using other variables is needed to explain more of the variance in LOS. No significant predictors contributed to LOS in the CCU in this study. This result may be due to other extraneous factors such as staffing, individual physician practice, the availability of telemetry beds, and the effects of other chronic diseases which may have delayed transfer from the CCU. Also, the identification of data related to other chronic diseases, history of a previous MI, prior coronary artery bypass grafting, and dysrhythmias were not collected. Future studies identifying these factors may strengthen study findings and more directly describe the variance in LOS.

One limitation of this study is that most of the glucose levels in the non-diabetic population were located on the basic metabolic panel. Because this panel was not always ordered daily or at the correct time to be considered "fasting," many blood glucose levels could not be included in this study as FBG. Another limitation of this study is the lack of postprandial blood glucose results to determine their possible influence on LOS. Unfortunately, the retrospective nature of the data collection in this study limited the ability to capture this information. Research that examines postprandial blood glucose levels may identify hyperglycemia not seen with the fasting glucose levels. A third component of metabolic syndrome, hyperlipidemia, was also not measured in this study. Because individuals with metabolic syndrome have increased cardiovascular risks (AHA, 2003), further research on the effects of metabolic syndrome in individuals with and without diabetes, as well as its relationship to LOS in patients with MI, is needed. Further studies in this area may identify even more opportunities to identify and treat hyperglycemia.

Results of this study increase awareness for early assessment of patients for hyperglycemia and complications related to hyperglycemia in an MI population. Medical-surgical nurses must be vigilant in recognizing hyperglycemia and collaborating with the rest of the health care team in monitoring, treatment patient education, and outpatient follow-up. Hyperglycemia in all patients should be taken seriously. However, because the patient with MI can present with many complications in the acute care setting, increased efforts to monitor glucose levels are warranted to affect outcomes and LOS.

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Table 1.

Demographic Data of Sample

	Sample with Diabetes (n=40; 32%)	Sample without Diabetes (n=84; 68%)	Total Sample (N=124)
Age (years)	66.1 (SD=11.4)	60.3 (SD=15.56)	62.2 (SD=14.57)
Race			
White	29 (72.5)	60 (71.4)	89 (71.8)
Black	9 (22.5)	18 (21.4)	27 (21.8)
Other	2 (5.0)	3 (3.6)	5 (4.0)
No race reported	--	3 (3.6)	3 (2.4)
Sex			
Female	19 (47.5)	30 (35.7)	49 (39.5)
Male	21 (52.5)	54 (64.3)	75 (60.5)
History of hypertension	37 (92.5)	49 (58.3)	86 (69.4)
History of			

smoking	17 (42.5)	45 (53.6)	62 (50.0)
Insulin infusion	2 (5.0)	0	0

Values are number of patients (percentage). Percentages may not total 100 due to rounding.

Table 2

Body Mass Index (BMI) Using National Heart, Lung, and Blood Institute (NHLBI) Guidelines

BMI (kg/mz)	Sample with Diabetes (n=40; 32%)	Sample without Diabetes (n=84; 68%)	Total Sample (N=124)
Underweight <18.5	1 (2.6)	5 (6.3)	6 (5.1)
Normal 18.5-24.9	14 (36.9)	23 (28.7)	35 (29.6)
Overweight 25-29.9	7 (18.4)	24 (30)	33 (28)

Obese			
30.0-34.9 High	5 (13.2)	20 (25)	25 (21.2)
35.9-39.9 Very High	6 (15.7)	7 (8.8)	13 (11)
[greater than or equal to] 40			
Extremely Obese	5 (13.2)	1 (1.2)	6 (5.1)
Missing data	2	4	6

Values are number of patients (percentage).

Percentages may not total 100 due to rounding

Source: National Heart, Lung, and Blood Institute, 1998

Table 3.

Multiple Regression Analysis of Co-Morbidities and Admission Blood Glucose's Influence on LOS (N=104)

	Standardized Regression Coefficient	Standard Error	t	p
Model 1				
Hypertension	0.285	0.163	2.982	0.004
Smoking	-0.040	0.149	-0.421	0.674

[R.sup.2]=0.085

p=0.011

F=4.709

Model 2

Hypertension	0.265	0.165	2.728	0.008
Smoking	-0.045	0.149	-0.475	0.636
Admission blood glucose ([dagger])	0.116	0.001	1.205	0.231

[R.sup.2]=.098

p=.015

F=3.638

([dagger]) = transformed