Correlation Between Admitting Blood Glucose Levels and Hospital Outcome in Patients who Underwent Percutaneous Coronary Intervention

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Abstract

Objectives: This study aimed to determine the correlation between admitting hyperglycemia and hospital outcome, on the length of hospital stay and mortality on patients who underwent PCI.

Methodology: A single center, retrospective observational study involving patients who underwent percutaneous coronary intervention (PCI). They were divided in four (4) groups according to presence of admission hyperglycemia (capillary blood glucose >140mg/dl) and presence of diabetes: Group 1 (patients with diabetes with admission hyperglycemia), Group 2 (patients without diabetes with admission hyperglycemia), Group 3 (patients with diabetes without admission hyperglycemia), and Group 4 (patients without diabetes without admission hyperglycemia). Length of hospital stay and mortality outcome were compared between four groups and in-hospital mortality related risk factors were analyzed by binary logistic regression analysis.

Results: 133 patients were included in the analysis, of which 50% have admission hyperglycemia. The length of hospital stay was significantly longer in patients with admission hyperglycemia (12 vs 9 vs 7 vs 7 days, *p= 0.006*). The mortality rate between 4 groups were non-significant (14% vs 10% vs 9% vs 11%, *p=0.272*). Multiple logistic regression analysis showed the following were associated with increased mortality in patients who underwent PCI: age (odds ratio [OR] 1.1265, 95%CI 1.0497 – 1.2090, *p=0.001*), capillary blood glucose on admission (OR 1.0077, 95% CI 1.0015 – 1.0140, *p= 0.015*), presence of ST elevation on ECG (OR 16.5671, 95% CI 3.4161 – 80.344, *p=<0.001*).

Conclusion: An elevated admission capillary blood glucose, regardless of presence or absence of diabetes, was associated with longer length of hospital stay; however, it was not predictive of in-hospital mortality. Interestingly, patients with admitting hyperglycemia had earlier mortality.

Keywords: Admission hyperglycemia, capillary blood glucose, diabetes mellitus, PCI

Introduction

Hyperglycemia is defined as blood glucose greater than 140 mg/dl.[1] Glucose metabolism is maintained by different interactions of glucoregulatory hormones – insulin and counterregulatory hormones. Hyperglycemia results from presence of excessive counterregulatory hormones (glucagon, growth hormone, catecholamines, and glucocorticoid) and elevated cytokines, which results in the failure of insulin to suppress hepatic gluconeogenesis.[2,3]

In-hospital hyperglycemia, in patients with and without diabetes, was noted to be associated with an increased risk of complications and mortality, longer hospital stays and higher rates of admission in the ICU as well as a higher need for transition care after discharge.[1] Stress hyperglycemia is common in critically ill patients and is noted to be a marker of disease severity. Critically ill and non-critically ill patients have demonstrated a strong association between stress hyperglycemia and poor clinical outcomes in terms of mortality, morbidity, length of stay, infections and overall complications.[4-11]

The predictive value of admission hyperglycemia to the prognosis of patients with acute coronary syndrome (ACS) have been conflicting in several studies.[1,6,21,25] There is less research on whether admission hyperglycemia has influence in the prognosis of ACS

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patients undergoing percutaneous coronary intervention (PCI) treatment. It also has not been well-established whether admission hyperglycemia is by itself a risk factor or a marker of illness severity. Therefore, this study aims to know the correlation between admitting blood glucose and hospital outcome, on the length of hospital stay and in-hospital mortality, of patients who underwent PCI.

Operational definition of terms

1. Admission hyperglycemia – presence of >140 mg/dl capillary blood glucose[12]
2. Presence of dyslipidemia–presence of >70mg/dl low density lipid (LDL) , or statin as maintenance
3. ST elevation Myocardial infarction (STEMI) – criteria for ST elevation MI on ECG are "presence of new ST-segment elevation at the J point in 2 contiguous leads with the cutoff point as greater than 0.1mV in all leads other than V2 or V3, in V2-V3 leads, the cutoff point is greater than 0.2 mV". STEMI is also considered in the presence of a new left bundle branch block.[22]
4. Positive troponin level – troponin level of >0.4 ng/ml in a patient presenting with chest pain
5. Smoking History – a person who was a previous smoker or a current smoker

Methods

This was a single-center, retrospective, observational study done in a 660-bed capacity tertiary hospital in Cebu City. The study subjects included patients with admitting capillary blood sugar who subsequently underwent PCI between January 2018 to November 2019. Patients who came in for symptoms of acute coronary syndrome and/or coronary artery disease, who subsequently underwent PCI. The study excluded patients who were scheduled for PCI, but without admission capillary blood glucose taken. Patients who were transferred for PCI. Patients who underwent PCI however transferred to another institution during the course of the admission. Patients whose medical records can't be retrieved.

Study Procedure: All patients who underwent PCI from January 2018 to November 2019 were obtained and charts were reviewed. Admitting capillary blood glucose (CBG) levels were noted. Patients were classified into four (4) groups, based on their history of diabetes and their blood glucose level on admission:

Group 1: Patients with diabetes with admission CBG > 140 mg/dl
Group 2: Patients without diabetes with admission CBG >140 mg/dl
Group 3: Patients with diabetes with admitting CBG ≤140 mg/dl
Group 4: Patients without diabetes with admitting CBG ≤140 mg/dl

Patients' clinical data regarding: age, gender, capillary blood glucose on admission, hemoglobin A1C (if present), presence of diabetes, hypertension, presence of dyslipidemia, positive or negative troponin status (if present), admitting creatinine level, smoking history, presence of ST elevation on ECG, vessels involved on angiography were obtained. The length of hospital stay and in-hospital mortality were analyzed among the four groups.

Ethical Considerations. The clinical protocol and all relevant documents were reviewed and approved by Chong Hua Hospital Institutional Ethics Review Committee. As respect to patient confidentiality, anonymity of patient records was ensured by assigning a unique code to each patient. The principal investigators were responsible for the integrity of the data that was recorded. Data collection forms were compiled and stored in an envelope. Data was tabulated in Microsoft Excel format and kept and filed by the principal author for 5 years before they are discarded.

Sample Size Calculation: Based on a level of significance of 5% and 7.5% desired half-width of the confidence intervals, a minimum of 113 patients were required for this study based on the 20.89% prevalence of mortality a month patient with undiagnosed diabetes.[1]

Data Processing and Analysis: Analysis was conducted using SPSS software. Data was expressed as mean values ±standard deviation for continuous variables and as percentages for categorical variables, and differences among the groups will be determined using Student's t-test. Frequencies and proportions will be reported for categorical variables and will be compared using chi-squared test. A two-tailed p value of <0.05 was considered to indicate statistical significance. One-way ANOVA with Tukey HSD test was used for post hoc analysis. Binary logistic regression analysis was used to examine determinants of in-hospital mortality and a multivariate analysis was done to determine the final model. Missing values were neither replaced nor estimated. Variables used for analysis included age, gender, capillary blood glucose on admission, diabetes medications, hypertension, presence of dyslipidemia, troponin status, admitting creatinine level, smoking history, presence of ST elevation on ECG, and vessels involved on angiography. The strength of association of glycemic status was assessed by comparison of the three groups with abnormal blood glucose profile to the Group 4 patients who had no diabetes and with admitting CBG ≤140 mg/dl.

Results

Two hundred sixty-four patients underwent percutaneous coronary intervention from January 2018 to December 2019. There were 132 patients excluded, of which 125 patients did not have admission blood glucose, 3 patients were transferred to another

Table I. The demographic profile of patients who underwent percutaneous coronary intervention, n=132

Parameter	Admission CBG >140 mg/dl Frequency (%); Mean ± SD		Admission CBG ≤140 mg/dl Frequency (%); Mean ± SD		p-value
	Diabetic patients (n = 56)	Non-diabetic patients (n = 10)	Diabetic patients (n = 22)	Non-diabetic patients (n = 44)	
Age, in years	64 ± 10.21	65 ± 12.10	63 ± 9.73	65 ± 13.36	0.964
Sex, Male, n (%)	40 (71)	7 (70)	14 (64)	37 (84)	0.896
Capillary Blood Glucose on Admission, mg/dl	245 ± 101.3	177 ± 27.82	111 ±14.36	111 ± 15	***<0.001***
HbA1c, %	8.13 ± 1.61	5.68 ± 0.39	6.34 ± 0.91	5.69 ± 0.37	***<0.001***
Presence of Dyslipidemia, n (%)	25 (45)	2 (20)	16 (73)	18 (41)	0.331
Hypertension, n (%)	47 (83.98)	7 70.00)	20 (90.91)	35 (79.55)	0.972
Smoking History, n (%)	17 (30)	4 (40)	7 (32)	16 (36)	0.949
Creatinine Value, mg/dl	1.72 ± 1.78	1.29 ± 0.31	2.34 ± 2.46	1.32 ± 0.68	0.092
Presence of ST elevation on ECG, n (%)	24 (43)	5 (50)	6 (27)	24 (55)	0.594
Infection prior to admission, n (%)	1 (2)	0	3 (14)	7 (16)	0.070
Infection during admission, n (%)	24 (43)	2 (20)	3 (14)	9 (20)	0.162
Coronary Vessels involved on Angiography, n (%)					
Left main	8 (14)	0	6 (27)	1 (2)	***0.037***
Left circumflex	31 (55)	7 (70)	14 (64)	18 (41)	0.686
Left anterior descending	49 (88)	6 (60)	17 (77)	36 (82)	0.928
Right coronary	40 (71)	3 (30)	13 (59)	21 (48)	0.486

Table II. Admitting capillary blood glucose (Mean ± SD) and length of hospital stay in patients who underwent percutaneous coronary intervention, n: 116

Characteristics	Admission CBG >140 mg/dl		Admission CBG ≤140mg/dl		p-value
	Diabetic patients (n = 48)	Non-diabetic patients (n = 9)	Diabetic patients (n = 20)	Non-diabetic patients (n = 39)	
Admitting Blood Glucose	235 ± 89.02	180 ± 27.23	109 ± 13.4	110 ± 14.7	***<0.001***
Total no. of days in Hospital Stay	12 ± 8.54	9 ± 5.04	7 ± 3.52	7 ± 4.61	***0.006***

institution, 3 patients were transferred from another institution, and 1 patient with missing record.

A total of 132 patients were divided according to the presence or absence of diabetes with or without admitting hyperglycemia. Group 1 had 56 (42.42%) patients with admission capillary blood glucose (CBG) >140 mg/dl and diabetes. Group 2 had 10 (7.58%) patients with admission CBG >140 mg/dl and non-diabetic. Group 3 had 22 (16.67%) patients with admission CBG ≤140 mg/dl and diabetes, and group 4 had 44 (33.33%) patients with admission CBG ≤140 mg/dl and non-diabetic.

For the length of hospital stay, 116 patients were analyzed, while 16 were analyzed for in-hospital mortality.

Patient Characteristics: Admission hyperglycemia was observed in 50% of the study population. The prevalence of diabetes in the study group was 59%. Patients' characteristics were presented into 4 study subgroups, as shown in *Table I*. The average age was 64 years old and males comprised 74% of the study population. The table also showed that the admitting capillary blood glucose (CBG) (245 mg/dl vs 177 mg/dl vs 111 mg/dl vs 111 mg/dl respectively with a $p < 0.001$) and HbA1c (8.13% vs 5.68% vs 6.34% vs 5.69% with a $p < 0.001$) were statistically significant. Left main involvement was more frequently noted in patients with diabetes.

The rest of the patients' clinical profiles were statistically the same; age, sex, presence of dyslipidemia, hypertension, smoking history, creatinine value, presence of infection before or during admission and presence of ST elevation MI.

While admission blood glucose and HbA1c were highest in group 1, HbA1c was lowest in group 2. Patients in group 3 had good diabetes control as reflected by a mean HbA1c of 6.23%.

Length of hospital stay. One hundred and sixteen patients were analyzed for the length of hospital stay. *Table II* showed that admitting blood glucose as well as the total number of hospital days were highest in Group 1. *Figure 1* is a scatter plot showing admitting glucose and the length of hospital stay in the four groups.

In-Hospital Mortality. Sixteen patients were analyzed for in-hospital mortality, with a mean duration of 9 days hospital stay, these are shown in *Table III*. The in-hospital mortality of the 4 groups were the same. Group 4 had oldest mean age of 79 years old, while group 2 had the youngest mean age of 61 years old. Patients with admission hyperglycemia regardless of the presence of diabetes (Group 1 and Group 2) had earlier mortality,

Table III. Mortality characteristics of patients who underwent PCI, n=16

Characteristics	Admission CBG >140		Admission CBG ≤140 mg/dl		p value
	Diabetic (Group 1)	Non-diabetic (Group 2)	Diabetic (Group 3)	Non-diabetic (Group 4)	
Mortality (%)	8 (14)	1 (10)	2 (9)	5 (11)	0.272
Age, years (SD)	64 ± 5.97	61	77 ± 7.5	79 ± 10.5	***0.018***
Admission CBG mg/dL	253 ± 83.4	146	129 ± 10	114 ± 12.8	***0.032***
Duration of hospital stay, days	3 ± 1.97	1	16 ± 3.5	17 ± 13.81	***0.004***

compared to those without admission hyperglycemia. *Figure 2* depicts the relationship between length of hospital stay and mortality.

Factors associated with mortality: Table IV demonstrated a simple logistic regression analysis of the factors associated with mortality in patients who underwent PCI. In this study, age, admission capillary blood glucose, positive troponin I levels and presence of ST segment elevation on ECG were associated with the risk of mortality. *Table V* showed the final multivariate logistic regression analysis, increasing age of the patient is significant with adjusted odds ratio of 1.13, admission capillary blood glucose levels is also significant with adjusted odds ratio of 1.0077, while the presence of ST segment elevation on ECG had adjusted odds ratio of 16 times higher than the absence of ST segment elevation.

Discussion

Admission hyperglycemia was noted in patients with and without diabetes who underwent percutaneous coronary intervention. In this study, 50% of the patients had admission hyperglycemia, in which 85% were patients with diabetes. As observed in some observational study, as much as 75% of patients with diabetes had admission hyperglycemia.[16-18] Males comprised 71% of the study population, the prevalence of ischemic heart disease was higher in men than in women. This could be because women are relatively protected from apoptosis and are noted to have experienced less cardiac remodeling than men, women were also noted to have more non-obstructive coronary artery disease than men.[19]Patients with diabetes with admission hyperglycemia had the highest blood glucose on admission as well as HBA1C levels compared to the other groups. Left main vessel involvement was also higher in patients with diabetes regardless of admitting glucose levels, similar findings were observed in a study review involving patients with stable angina or acute coronary syndrome.[19]

For the length of hospital stay, 84% of the patients with admission hyperglycemia were patients with diabetes. It was also determined that admission hyperglycemia, regardless of presence or absence of diabetes was associated with longer length of hospital stay (12 days vs 9 days vs 7 days vs 7 days with a *p=0.008*). Similar findings were noted in Taiwan, noting longer duration of hospital stay in STEMI patients with admission hyperglycemia after PCI. Among patients not known to have diabetes, hyperglycemia might reveal previously undiagnosed diabetes, stress hyperglycemia or combination of both. Stress hyperglycemia might be one of the explanations for the longer hospital stay in patients not diagnosed with diabetes presenting with elevated admission capillary blood glucose (9 days).[20] Stress hyperglycemia has been associated with inducing arrhythmias, impaired left ventricular function, larger infarct size, increased platelet activation, activation of blood coagulation.[22]

In this study, it was noted that patients with diabetes but with admission CBG of ≤140 mg/dl had a short length of hospital stay (7 days), these patients also had good diabetes control as reflected by a mean HBA1C of 6.34. This result was also reflected in a study by Corpus et al, noting optimal glycemic control being associated with improved clinical outcome after PCI.[23]

Contrary to several studies, our results showed no increase in in-hospital mortality in patients with admission hyperglycemia compared to those with euglycemia on admission.[6,8,20] These could probably be due to enhancement in acute clinical care, advances in more intensive medical procedures like revascularization approaches, as reflected by a study done in the United States noting a substantial decline in diabetes-related complications in the past two decades.[24] Interestingly, a study by Whitcomb et al. revealed that admission hyperglycemia was not significantly

Table IV. Factors associated with mortality in patients who underwent PCI using simple logistic regression

Factor	Odds Ratio (95% CI)	p-value
Age	1.0617 (1.0096 - 1.1165)	***0.020***
Capillary Blood Glucose on admission	1.0047 (1.0002 - 1.0093)	***0.043***
Positive Troponin I	9.1667 (1.1699 - 71.827)	***0.035***
Presence of ST elevation on ECG	6.8370 (1.8452 - 25.333)	***0.004***

Table V. Factors associated with mortality in patients who underwent PCI using multiple logistic regression analysis

Factor	Odds Ratio (95% CI)	p-value
Age	1.1265 (1.0497 - 1.2090)	***0.001***
Capillary Blood Glucose on admission	1.0077 (1.0015 - 1.0140)	***0.015***
Presence of ST elevation on ECG	16.5671 (3.4161 - 80.344)	***<0.001***

associated with elevated mortality among patients with previous history of diabetes. In that study, they noted a statistically significant lower mortality rates in patients with admission hyperglycemia with diabetes relative to those with euglycemic patients. It is highly possible these patients with known diabetes and admission hyperglycemia are likely to receive intensive insulin treatment during their stay.[25]

In addition, we also determined that admission capillary blood glucose of >140 mg/dl, regardless of presence or absence of diabetes, was associated with earlier mortality. In our study, patients with admission hyperglycemia (groups 1 and 2) had earlier mortality, hence shorter hospital stay, compared to patients who were euglycemic on admission (group 3 and 4). Poor outcome in patients with diabetes with admission CBG >140 mg/dl is primarily related to the harmful effects of diabetes on myocardium.[8]

In this study, it was determined that age, presence of ST elevation myocardial infarction and admission capillary blood glucose level were associated with in-hospital mortality. Similar results were also found in several studies.[1,4,5,8,10,21,26] A study in Japan also noted similar findings noting admission hyperglycemia irrespective of the presence or absence of diabetes was an independent predictor of in-hospital mortality.[8] In similar studies in Taiwan, the authors found out that in-hospital mortality rate was even higher in patients without previously known diabetes with admission glucose levels of ≥250mg/dl.[20] Similar findings were also noted in a study in Spain that admission blood glucose ≥140mg/dl exhibited a 2-fold increase of in-hospital mortality risk irrespective of diabetes mellitus status.[27]

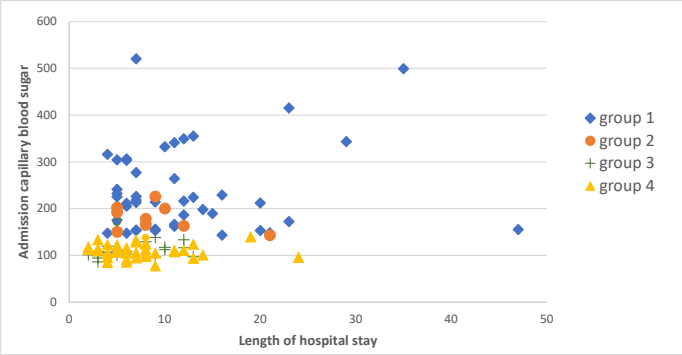

Figure 1. Scatterplot of Admission capillary blood sugar and Length of Hospital Stay

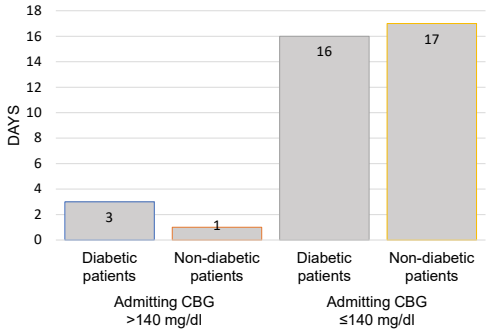

Figure 2. Mortality and duration of hospital stay of the four groups based on Admitting CBG and presence of diabetes

Conclusion

Admission hyperglycemia was associated with longer length of hospital stay, however, was not associated with increased in in-hospital mortality, in patients who underwent percutaneous coronary intervention. Age, admission hyperglycemia and presence of ST elevation MI were associated were predictors of mortality.

Interestingly, admission hyperglycemia was associated with earlier mortality.

These findings emphasize the steady need for aggressive risk reduction and integrated management of care in people with diabetes.

Limitations and Recommendations

This study has several limitations. First, the data retrieval was retrospective in nature, hence, the information is limited to what was written on the patient's charts. Furthermore, many charts were excluded due to the absence of admission capillary blood glucose, patients transferred to another institution and were transferred from another institution. In addition, the retrospective design of this study prevented further analysis of factors related to the outcome. Although the sample size was met with this study, a longer prospective and larger size is recommended to further elucidate the effects of admission hyperglycemia in a tertiary hospital setting.

There were only 4 elective procedures in this study, thus this did not make an impact on the result.

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References

1. Umpierrez GE, Isaacs SD, Bazargan N et al; Hyperglycemia: An independent marker of in- hospital mortality in patients with undiagnosed diabetes. J Clin Endocrinol Metab2002; 87(3):978-982.
2. Marik P, Bellorno R; Stress hyperglycemia: an essential survival response!.CriticalCare 2013, 17:305
3. Corsino L, Dhatariya K, Umpierrez G; Management of Diabetes and Hyperglycemia in Hospitalized Patients. [Updated 2017 Oct 1]. In: Feingold KR, Anawalt B, Boyce A, et al., editors. Endotext [Internet]. South Dartmouth (MA): MDText.com, Inc.; 2000-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK279093/
4. Hao Y, Lu Q, Li T, Yang Goudong, Hu Peijing, Ma A; Admission hyperglycemia and adverse outcomes in diabetic and non-diabetic patients with non-ST-elevation myocardial infarction undergoing percutaneous coronary intervention.BMC Cardiovascular Disorders (2017) 17:6 DOI 10.1186/s12872-016-0441-x
5. Ding XS, Wu SS, Chen H, Zhao XQ, Li HW; High admission glucose levels predict worse short-term clinical outcome in non-diabetic patients with acute myocardial infarction: a retrospective observation study.BMC Cardiovascular Disorders (2019) 19:163 https://doi.org/10.1186/s12872-019-1140-1
6. Gong X, Chen P, Zhang Y, Xiao J, Li W, Xue Q, Wang A, Wang Z; Correlation between blood glucose levels on admission and short-term prognosis of in-patients with acute coronary syndromes after percutaneous coronary intervention.Biomedical Research 2017; 28 (1):357-362
7. Madani M, Alizadeh K, Ghazaee SP, Zavarehee A, Abdi S, Shakerian F, Salehi N, Firouzi A; Elective Percutaneous Coronary Intervention The relationship between Preprocedural Blood Glucose Levels and Periprocedural Myocardial Injury.Tex Heart Inst J 2013;40(4):410-7
8. Kosuge M, Kimura K, Kojima S, Sakamoto, T, Matsui K, Ishihara M, Asada Y, Tei C, Miyaaki S, Sonoda M, Tsuchihashi K, Yamagishi M, Ikeda, Y, Shirai M, Hiraoka H, Inoue T, Saito F, Ogawa H; Effects of Glucose Abnormalities on In-Hospital Outcome After Coronary Intervention for Acute Myocardial Infarction. Circ J 2005; 69:375-379
9. Goyal A, Mahaffey KW, Garg J; Prognostic significance of the change in glucose level in the first 24 h after acute myocardial infarction: results from the CARDINAL study. Europ heart J 2006; 27: 1289-1297
10. Zorbozan O, Cevik A, Acar N, Ozakin E, Ozcelik H, Birdane A, Abu-Zidan F; Predictors of mortality in ST-elevation MI patients: A prospective study. Medicine (2018) 97:9doi:10.1097/md.0000000000010065.
11. American Diabetes Association. 15. Diabetes Care in the Hospital: Standards of Medical Care in Diabetes—2020. Diabetes Care 2020 Jan; 43(Supplement 1): S193-S202.https://doi.org/10.2337/dc20-S015
12. Boden G; Gluconeogenesis and glycogenolysis in health and diabetes.J Investig Med 2004; 52(6):375-378.
13. Hulkower RD, Pollack RM, Zonszein J; Understanding hypoglycemia in hospitalized patients.Diabetes Manag (Lond) 2014; 4(2):165-176.
14. McCowen K, Malhotra A, Bistrian B; Stressed-induced hyperglycemia. Critical Care Clinics, Elvesier, 22 Aug. 2005, www.sciencedirect.com/science/article/pii/S0749070405701549 8
15. Swanson C, Potter D, Kongable G, Cook C; Update on inpatient glycemic control in hospitals in the United States. EndocrPract2017; 17(6):853-861.
16. Schmeltz LR, DeSantis AJ, Thiyagarajan V et al; Reduction of surgical mortality and morbidity in diabetic patients undergoing cardiac surgery with a combined intravenous and subcutaneous insulin glucose management strategy. Diabetes Care 2007; 30(4):823.
17. Carpenter DL, Gregg SR, Xu K, Buchman TG, Coopersmith CM; Prevalence and impact of unknown diabetes in the ICU.Crit Care Med 2015; 43(12):e541-e550.
18. Dunlay S, Roger V; Gender differences in the pathophysiology, clinical presentation, and outcomes of ischemic heart failure.Curr Heart Fail Rep. 2012 December ; 9(4): 267–276. doi:10.1007/s11897-012-0107-7.
19. Soleimani A[1], Abbasi A, Kazzazi EH, Hosseini K, Salirifar M, Darabian S, Sadeghian S, Sheikhfathol-Lahi M; Prevalence of left main coronary artery disease among patients with ischemic heart disease: insights from the Tehran Angiography Registry.Minerva Cardioangiol. 2009 Apr;57(2):175-83. PMID: 19274028
20. Chen PC, Chua SK, Hung HF, Huang CY, Lin CM, Lai SM, Chen YL, Cheng JJ, Chiu CZ, Lee SH, Lo HM, Shyu KG; Admission Hyperglycemia Predicts Poorer Short- and Long-Term Outcomes after Primary Percutaneous Coronary Intervention for ST-Elevation Myocardial Infarction. Journal of Diabetes Investigation, Wiley-Blackwell, 12 Feb. 2014, www.ncbi.nlm.nih.gov/pmc/articles/PMC4025238/.
21. Antonio Ceriello; Acute hyperglycaemia: a 'new' risk factor during myocardial infarction, European Heart Journal, Volume 26, Issue 4, February 2005, Pages 328–331, https://doi.org/10.1093/eurheartj/ehi049
22. Foth C, Mountfort S; Acute Myocardial Infarction ST Elevation (STEMI) [Updated 2019 Nov 1]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK532281/
23. Corpus RA[1], George PB, House JA, Dixon SR, Ajluni SC, Devlin WH, Timmis GC, Balasubramaniam M, O'Neill WW; Optimal glycemic control is associated with a lower rate of target vessel revascularization in treated type II diabetic patients undergoing elective percutaneous coronary intervention. J Am Coll Cardiol. 2004 Jan 7;43(1):8-14. DOI: 10.1016/j.jacc.2003.06.019
24. Gregg EW, Li Y, Wang J, Burrows NR, Ali MK, Rolka D, et al. Changes in diabetes-related complications in the United States, 1990–2010. N Engl J Med. 2014; 370:1514–23.
25. Whitcomb BW, Pradhan EK, Pittas AG, Roghmann MC, Perencevich EN. Impact of admission hyperglycemia on hospital mortality in various intensive care unit populations. Crit Care Med. 2005 Dec;33(12):2772-7. doi: 10.1097/01.ccm.0000189741.44071.25. PMID: 16352959.
26. Ali M, Lange SA, Wittlinger T, Lehnert G, Rigopoulos AG, Noutsias M. In-hospital mortality after acute STEMI in patients undergoing primary PCI. Herz. 2018 Dec;43(8):741-745. English. doi: 10.1007/s00059-017-4621-y. Epub 2017 Oct 9. PMID: 28993843.
27. Sanjuán, Rafael, et al. "Prognostic Implications of Stress Hyperglycemia in Acute ST Elevation Myocardial Infarction. Prospective Observational Study." Revista Española De Cardiología (English Edition), vol. 64, no. 3, 2011, pp. 201–207., doi: 10.1016/j.rec.2010.08.005.