Original Article

HEALTH SCIENCES
MEDICINE

DOI: 10.32322/jhsm.953157
J Health Sci Med 2021; 4(5): 698-702

# The effect of blood gas analysis and Charlson comorbidity index evaluation on the prediction of hospitalization period in patients with diabetic hyperglycemic crisis

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**Cite this article as**: Hökenek NM, Ak R. The effect of blood gas analysis and Charlson comorbidity index evaluation on the prediction of hospitalization period in patients with diabetic hyperglycemic crisis. J Health Sci Med 2021; 4(5): 698-702.

## ABSTRACT

**Objective**: This study aims to evaluate the effectiveness of blood gas analysis at the time of admission and additional Charlson comorbidity index (CCI) in predicting the hospitalization period of patients admitted to the emergency department (ED) with a hyperglycemic crisis.

**Material and Method:** This study was designed as retrospective, cross-sectional and observational. The patients who admitted to the ED with hyperglycemic crisis (diabetic ketoacidosis and hyperosmolar hyperglycemic syndrome) and hospitalized were included in the study within 2 years between January 1, 2019, and January 1, 2021, in a tertiary research hospital

**Results**: A total of 93 patients included in this study, which of 48 (51.6%) were female and 45 (48.4%) were male. The mean age of the patients was 63.49±26.59. The mean hospitalization period was determined as 6.25±5.16 days. In total, 7 patients (7.5%) were followed up in the intensive care unit (ICU), while mortality was observed in 2 (2.15%) of these patients. It was determined that there was a statistically significant association between hospitalization period of the patients and their findings such as age (r=0.879, p<0.001), Charlson index (r=0.708, p<0.001), PH value (r=0.312, 0.002), $HCO_3$ value (r=0.316, p=0.002), BE value (r=-0.315, p=0.002).

**Conclusion**: It can be predicted that patients who admitted to the ED with DKA and HHS will have a long hospitalization according to blood gas analysis evaluation and presence of comorbidities. Additionally, the quality of treatment can be increased by measures such as education, early consultation of the diabetes team and early detection of triggering factors.

**Keywords**: Blood gas analysis, diabetic ketoacidosis, hyperosmolar hyperglycemic syndrome, length of stay, emergency department

## INTRODUCTION

Diabetes is a disease that affects public health with a rising trend in the world. According to the World Health Organization (WHO) data, it is the 9th most common cause of mortality worldwide in 2019 (1), and it caused an economic burden of approximately 327 billion dollars with 40.3 million patients in the USA in 2017. therefore, It is required to be controlled since both its high cost and the loss of workforce. It has been revealed that uncontrolled diabetes patients have negative outcomes such as extension of hospitalization, increased mortality and morbidity (2). Studies are reporting that even the presence of diabetes alone causes side effects on many systems of the human body (3). There are many studies conducted to predict these side effects (4,5). However, the fact that 25-30% of all hospitalized patients are diagnosed with diabetes reveals that diabetes alone is an important factor that should be evaluated during hospitalization (6). Acute glycemic changes have been proved to be the primary cause in 4-9% of hospitalized diabetes patients.

In this determination, mainly two clinical syndromes emerged. Diabetic ketoacidosis (DKA) and Hyperosmolar hyperglycemic state (HHS) are the most severe acute metabolic complications of diabetes (6). The DKA is one of the preeminent hyperglycemic complications related to diabetes (7) and consists of metabolic acidosis, hyperlactatemia, ketonuria and ketonemia (8). It is caused for more than 500,000 hospitalizations by a year (9). Hyperosmolar hyperglycemic syndrome (HHS) is characterized by high glucose and osmolarity, as well as the absence of ketoacidosis (10). Relative insulin deficiency in HHS causes more osmotic diuresis and dehydration than DKA (11).

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**Received:** 16.06.2021 **Accepted:** 18.07.2021

These 2 clinical conditions are important metabolic conditions that may cause diabetic patients to admitted with hyperglycemic coma. In fact, in DKA and HHS, besides insulin deficiency, it occurs as a result of an increase in counterregulatory hormones (glucagon, catecholamines, cortisol and growth hormone). The increase in these counterregulatory hormone levels also causes different hemodynamic and metabolic disorders. This is another cause why the clinical course of patients is challenging to manage. Therefore, DKA and HHS are syndromes that endanger patient life and require urgent hospitalization. Predicting the hospitalization period in these patients is important in terms of more aggressive approaches in treatment modalities, and earlier evaluation of patients by endocrinology specialists or a diabetes team (12). However, these rates reveal different results such as 3-13% in developing countries, in children or individuals over 60 years of age with comorbid diseases (13-15). Mortality rates due to HHS vary as 5-16%. The high mortality rates of both clinical conditions are required early intervention (12).

It has been not revealed a gold standard method for evaluating the effects of comorbid diseases on mortality and hospitalization period. However, the CCI has been practiced for many years to evaluate the effects of comorbid diseases on mortality, re-admission, and hospitalization period (16). The updated CCI evaluates 12 comorbid diseases (17). Comorbidities are scored from 1 to 6 to assess mortality risk and disease severity. Conclusively, these values are summed for each patient and the total score is reached. In patients with a CCI score of 5 and above, while 1-year mortality was found as 85%, the 10-year survival was found as 34% (16).

The primary aim of our study is to evaluate the effect of blood gas analysis and comorbidities in predicting the hospitalization period of patients admitted to the ED with a hyperglycemic crisis.

## MATERIAL AND METHOD

Ethics committee approval was obtained from Health Sciences University, Kartal Dr. Lütfi Kırdar City Hospital Non-interventional Research Ethics Committee (Date: 28.04.2021, Decision No: 2021/514/200/22) granted the relevant approval to our study. We carefully minded that all procedures applied in this study complied with the 1964 Helsinki Declaration and the ethical standards of the National/Institutional Scientific Research Committee.

### Patients

This study was designed as a retrospective, cross-sectional and observational. The patients who admitted to the ED with hyperglycemic crisis (diabetic ketoacidosis and hyperosmolar hyperglycemic syndrome) were included in the study within 2 years between January 1, 2019, and January 1, 2021, in a tertiary research hospital.

In the first blood gasses of the patients at the time of admission, the values such as pH, $PCO_2$, lactate, base deficit, $HCO_3$ and disease histories and risk of comorbidities were scanned from the hospital automation system. All patients were treated with standard approaches in the ED. Blood gas analyzes of all patients have performed with the ABL 800 FLEX blood gas analyzer (Radiometer, Copenhagen, Denmark) device. It was researched whether the patients had a chronic disease such as hypertension, myocardial infarction, congestive heart failure, cerebrovascular disease, dementia, chronic obstructive pulmonary disease, chronic liver disease, hemiplegia, chronic kidney disease, solid tumour, leukaemia and lymphoma in their disease histories. CCI values were then calculated using these data.

### Inclusion Criteria

Being over 18 years old and being admitted to the ED with hyperglycemic crisis (diabetic ketoacidosis and hyperosmolar hyperglycemic syndrome) with ICD codes [E10.1, E11.1, or E13.1 (diabetic ketoacidosis) or E11.0, E13.0, or E10.65 and E10.69 (hyperosmolar hyperglycemic syndrome)], after diagnosed and hospitalized.

### Exclusion Criteria

Being under the age of 18 and being the one whose disease histories could not be reached by blood tests from the hospital automation system.

When diagnosing DK and hyperosmolar hyperglycemic syndrome, the guidelines of the American Diabetes Association were based on (10). For DK, plasma glucose >250 mg/dl, arterial pH<7.3 serum $HCO_3$ <18, urine ketone positivity criteria are accepted, for the hyperosmolar hyperglycemic syndrome, glucose level >600 mg/dL, plasma effective osmolarity >320 mOsm/L, and an absence of significant ketoacidosis was accepted (10). The CCI scores of the patients were calculated using MedCalc 12.3.0.0 for Windows (MedCalc Software, Mariakerke, Belgium). The sample size in the study was calculated by considering both the number of in-hospital patients for 2 years and the numbers in similar studies (19).

### Statistical Analysis

R version 2.15.3 program (R Core Team, 2013) was performed for statistical analysis. Minimum, maximum, mean, standard deviation, median, first quartile, third quartile, frequency and percentage were used when reporting the study data. The conformity of the quantitative data to the normal distribution was assessed with the Shapiro-Wilk test and graphical examinations. The Mann-Whitney U test was practiced to evaluate the variables that did not show normal distribution between the two groups. Pearson correlation analysis was used to determine the level of association between quantitative variables. Statistical significance was accepted as $p<0.05$.

## RESULTS

After scanning the data of patients with ICD codes from the hospital automation system, the information of 96 patients were reached. One patient whose disease history data could not be reached and two patients who were transferred to another hospital during the treatment period were excluded from the study. There were 93 patients included in the study, which of 48 were female (51.6%) and 45 were male (48.4%). The mean age of the patients was 63.49±26.59. The mean hospitalization period was determined as 6.25±5.16 days. In total, 7 patients (7.5%) followed up in the ICU, while mortality was observed in 2 patients (2.15%) (**Table 1**). It was determined that there was a statistically significant association between hospitalization period of the patients and their findings such as age (r=0.879, p<0.001), Charlson index (r=0.708, p<0.001), pH value (r=0.312, 0.002), $HCO_3$ value (r=0.316, p=0.002), BE value (r=-0.315, p=0.002). There was no statistically significant correlation was found between the hospitalization period and the lactate and $PCO_2$ values in blood gas at the time of admission (p>0.05). There was no statistically significant difference in terms of hospitalization period according to gender and ICU condition of the cases (p>0.05) (**Table 2**).

**Table 1.** Characteristics of patients

| | Min-Max | Mean±ss |
|---|---|---|
| Age | 18-109 | 63.49±26.59 |
| Hospitalization period | 1-25 | 6.25±5.16 |
| Charlson index | 2-9 | 2.73±1.35 |
| PH | 6.91-7.49 | 7.3±0.14 |
| Lactate | 0.7-6.7 | 2.51±1.18 |
| $HCO_3$ | 5.5-30.1 | 19.67±7.05 |
| BE | 0-28 | 8.08±8.28 |
| $PCO_2$ | 9.1-58.6 | 37.28±11.66 |
| | **n** | **%** |
| Gender | | |
| Female | 48 | 51.6 |
| Male | 45 | 48.4 |
| Mortality | 2 | 2.15 |
| ICU | 7 | 7.5 |
| HT | 42 | 45.2 |
| SVO | 4 | 4.3 |
| KBY | 2 | 2.2 |
| Cirrhosis | 0 | 0.0 |
| Malignancy | 7 | 7.5 |
| KKY | 7 | 7.5 |
| COPD | 4 | 4.3 |
| Alzheimer/demands | 0 | 0.0 |
| Immune suppression | 1 | 1.1 |
| Rheumatic diseases | 2 | 2.2 |
| Hemiplegia/paraplegia | 0 | 0.0 |
| Peripheral vascular disease | 1 | 1.1 |

**Table 2.** The association of blood gas and CCI with hospitalization period

| | r | [a]p |
|---|---|---|
| Age | 0.879 | <0.001* |
| Charlson index | 0.708 | <0.001* |
| PH | 0.312 | 0.002* |
| Lactate | 0.133 | 0.203 |
| $HCO_3$ | 0.316 | 0.002* |
| BE | -0.315 | 0.002* |
| $PCO_2$ | 0.199 | 0.055 |
| | **Median (Q1, Q3)** | **[b]p** |
| Gender | | 0.126 |
| Female | 5 (3, 9) | |
| Male | 3 (2, 8) | |
| ICU | | 0.216 |
| No | 4 (3, 8) | |
| Yes | 11 (1, 14) | |

[a]Pearson correlation analysis, [b]Mann-Whitney U test, results are presented (as first quarter, third quarter). *p<0.0

## DISCUSSION

In this study, which evaluated the prediction of hospitalization period and blood gas at the time of admission to the ED, a strong correlation was found between especially age, Ph, $HcO_3$, BE and CCI (p<0.005). According to these results, the requirement for longer hospitalization in the early period can be predicted by evaluating the blood gases at the time of admission and additional diseases of the patients. This knowledge can lead to changes in patient management.

Diabetes is a complex and chronic disease that requires constant medical support (20). Diabetic hyperglycemic crisis patients are diagnosed after their admission to the ED and treated according to standard approaches. However, the treatment period can be completed by following many different factors together (21). Early prediction of hospitalization period, evaluation by the diabetes team, education, and prevention of triggering events to prevent future attacks are significant precautions (21). When all these precautions are completed, the treatment will be completed (21). Thus, it can contribute to reducing the economic burden of diabetic patients on the health system and relieving the workforce.

Important limitations of this research are that it was a retrospective study and evaluated a limited population of patients.

The blood gas analysis is a rapid, inexpensive and effective test in evaluating the patient. It is practiced to evaluate the metabolic status in the diagnosis of DKA and HHS. There are studies in the literature determining the relationship between blood gas variables and 30-day mortality, especially in DKA (22). In a single-center study involving a limited population, lactate clearance in the first two hours was associated with 30-day mortality (22).

CCI calculates a score based on patients' age and comorbidities. It uses it to predict patients' in-hospital-, 1-year and 10-year mortality. CCI is objective and covers both systemic and localized disease while allowing for the adjustment of age (23).

In our study, it was determined that the changes in Ph, $HCO_3$, BE values in the blood gas analysis were significantly associated with the hospitalization period. According to the conclusions of our study, potential increase in hospitalization period may be predicted by the blood gas analysis and additional disease information that can be easily accessed after the ED admission of the patients. The current guideline of the American Diabetes Association suggests that all patients hospitalized for diabetes should be assessed by a specialized diabetes team in the early stage (24,25). In a study evaluating the effect of diabetology consultation in the first 48 hours on the hospitalization period, it was determined that the average hospitalization period of the patients who were consulted was 1.56 days less (26). According to this result and our study, the average hospitalization period can be shortened if the first blood gas analysis and comorbidities and the patients who are predicted to be a long hospitalization period are recognized in the early period and a diabetes consultation is performed. Cost-effectiveness can also be achieved with measures to be taken especially in the management of patients who are expected to have a long hospitalization period.

## CONCLUSION

It can be predicted that patients who admitted to the ED with DKA and HHS will have a long hospitalization period according to blood gas analysis evaluation and presence of comorbid diseases. In particular, there is a strong correlation between the patient's age and the Ph, $HcO_3$, BE blood gas at the time of admission and CCI. Factors such as patient education and early evaluation by the diabetes team may shorten the hospitalization period.

## ETHICAL DECLARATIONS

**Ethics Committee Approval:** Approval was obtained from Kartal Dr. Lütfi Kırdar City Hospital Non-interventional Researchs Ethics Committee (Date: 28.04.2021, Decision No: 2021/514/200/22)

**Referee Evaluation Process:** Externally peer-reviewed.

**Conflict of Interest Statement:** The authors have no conflicts of interest to declare.

**Financial Disclosure:** The authors declare that this study has received no financial support.

**Author Contributions:** All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved its final version.

## REFERENCES

1. Arslanian S, Bacha F, Grey M, Marcus MD, White NH, Zeitler P. Evaluation and management of youth-onset type 2 diabetes: a position statement by the American Diabetes Association. Diabetes Care 2018; 41: 2648-68.
2. Endocrinologists AAoC. American Association of Clinical Endocrinologists and American Diabetes Association consensus statement on inpatient glycemic control. Diabetes Care 2009; 32.
3. Kalkan S, Karatay E, Akbal E. Increased gastrointestinal symptom frequency in diabetes mellitus even with good glycemic control.J Health Sci Med 2020; 3: 26-30.
4. Yiğenoğlu TN, KEBAPÇI MN, Hülya Ö. The significance of ankle-brachial index in determining peripheral artery disease in patients with type 2 diabetes mellitus over 40 years of age and the relationship of peripheral artery disease with chronic complications of diabetes. J Health Sci Med 2020; 3: 115-20.
5. Handan A, YILMAZ S, Can FK, Parlak M. An evaluation of risk factors affecting amputation in patients with diabetic foot Infection. J Health Sci Med 2021; 4: 49-54.
6. Draznin B, Gilden J, Golden S, Inzucchi S, Baldwin D, Bode B. for the PRIDE investigators. Pathways to quality inpatient management of hyperglycemia and diabetes: a call to action Diabetes Care 2013; 36: 1807-14.
7. Kitabchi AE, Wall BM. Diabetic ketoacidosis. Med Clin North Am 1995; 79: 9-37.
8. Gosmanov AR, Gosmanova EO, Dillard-Cannon E. Management of adult diabetic ketoacidosis. Diabetes Metab Syndr Obes 2014; 7: 255.
9. Kim S. Burden of hospitalizations primarily due to uncontrolled diabetes: implications of inadequate primary health care in the United States. Diabetes care 2007; 30: 1281-2.
10. Kitabchi AE, Umpierrez GE, Miles JM, Fisher JN. Hyperglycemic crises in adult patients with diabetes. Diabetes care 2009; 32: 1335-43.
11. Patel M. Emergencies in diabetes–diabetic ketoacidosis and hyperosmolar hyperglycaemic state. Medicine 2020; 49: 106-9.
12. Umpierrez G, Korytkowski M. Diabetic emergencies—ketoacidosis, hyperglycaemic hyperosmolar state and hypoglycaemia. Nat Rev Endocrinol 2016; 12: 222.
13. Benoit SR, Zhang Y, Geiss LS, Gregg EW, Albright A. Trends in diabetic ketoacidosis hospitalizations and in-hospital mortality—United States, 2000–2014. Morbidity and Mortality Weekly Report 2018; 67: 362.
14. Zhong VW, Juhaeri J, Mayer-Davis EJ. Trends in hospital admission for diabetic ketoacidosis in adults with type 1 and type 2 diabetes in England, 1998–2013: a retrospective cohort study. Diabetes Care 2018; 41: 1870-7.
15. Poovazhagi V. Risk factors for mortality in children with diabetic keto acidosis from developing countries. World J Diabetes 2014; 5: 932.
16. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis 1987; 40: 373-83.
17. Quan H, Li B, Couris CM, Fushimi K, Graham P, Hider P, et al. Updating and validating the Charlson comorbidity index and score for risk adjustment in hospital discharge abstracts using data from 6 countries.Am J Epidemiol 2011; 173: 676-82.
18. Lange SJ, Ritchey MD, Goodman AB, Dias T, Twentyman E, Fuld J, et al. Potential indirect effects of the COVID-19 pandemic on use of emergency departments for acute life-threatening conditions—United States, January–May 2020. Wiley Online Library; 2020.
19. Siregar NN, Soewondo P, Subekti I, Muhadi M. Seventy-two hour mortality prediction model in patients with diabetic ketoacidosis: a retrospective cohort study. J ASEAN Fed Endocr Soc 2018; 33: 124.

20. Riddle MC, Bakris G, Blonde L, Boulton A. American Diabetes Association standards of medical care in diabetes–2019. Diabetes Care 2019; 42: 34-60.
21. French EK, Donihi AC, Korytkowski MT. Diabetic ketoacidosis and hyperosmolar hyperglycemic syndrome: review of acute decompensated diabetes in adult patients. Bmj 2019; 365: I1114.
22. Ibrahim A, Bayramoglu B, Hokenek NM, Tekyol D. Lactate clearance during the first 2 hours after hospital admission: A useful biomarker for predicting 30-day mortality in patients with diabetic ketoacidosis. Int J Clin Pract 2021: e14204.
23. Quan H, Li B, Couris CM, et al. Updating and validating the Charlson comorbidity index and score for risk adjustment in hospital discharge abstracts using data from 6 countries. Am J Epidemiol 2011; 173: 676-82.
24. Bansal V, Mottalib A, Pawar TK, et al. Inpatient diabetes management by specialized diabetes team versus primary service team in non-critical care units: impact on 30-day readmission rate and hospital cost. Bmj Open Diab Res Ca 2018; 6.
25. Flanagan D, Moore E, Baker S, Wright D, Lynch P. Diabetes care in hospital—the impact of a dedicated inpatient care team. Diabet Med 2008; 25: 147-51.
26. Sheahan KH, Atherly A, Dayman C, Schnure J. The impact of diabetology consultations on length of stay in hospitalized patients with diabetes.Endocrinol Diabetes Metab 2021; 4: e00199.