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Research Article

Investigation of the Effect of Acute to Chronic Glycemic Ratio on the Development of Postoperative Pneumonia After Stanford Type A Acute Aortic Dissection Surgery

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Abstract

Aim: A critical clinical condition called acute Type A aortic dissection (ATAAD) necessitates quick surgical action. Other significant issues include the emergence of postoperative pneumonia and various organ failures. We sought to determine how well the ratio of admission blood glucose (ABG) to estimated average glucose (eAG) might be used to anticipate postoperative pneumonia following ATAAD surgery.

Materials and Methods: The study comprised patients who underwent ATAAD surgery between January 2016 and January 2022. In the postoperative phase, patients were divided into two groups: Group 1 for those who did not acquire pneumonia and Group 2 for those who did.

Results: The study involved 124 patients in total. Group 1 [N = 92, median age = 51 (32 to 80) years] consisted of those who did not acquire postoperative pneumonia, but Group 2 [N = 32, median age = 53 (30 to 77)] did. ABG/eAG ratio and ventilation time were found to be independent predictors of postoperative pneumonia by multivariate analysis [(OR: 0.886, CI 95%: 0.695-0.990, P=0.009) and (OR: 1.114, 1.030-1.542, P=0.023)].

Conclusion: We demonstrated that ABG/eAG ratio, calculated at admission time, is a significant predictor of the development of postoperative pneumonia.

Keywords: Pneumonia, risk factor, type A acute aortic dissection, glucose

INTRODUCTION

Acute Type A aortic dissection (ATAAD) is an important clinical condition that requires urgent surgical intervention. Even with modern technology, death and morbidity rates remain high (1). Mortality after these operations is the most catastrophic outcome. In addition, various organ failures and the development of postoperative pneumonia are also important problems (2).

Cardiovascular illnesses have higher mortality and morbidity due to disturbances in glucose metabolism. In addition, prothrombotic events and an increase in oxidative stress brought on by acute hyperglycemia result in endothelial dysfunction. Whether or not someone has diabetes mellitus (DM), this circumstance has a negative impact on the prognosis following acute cardiovascular events. Recent research in this area has demonstrated the significance of admission blood glucose (ABG)/estimated average glucose (eAG) values in the prognosis of acutely developing cardiovascular events (3,4). Another finding from a study was the connection between admission hyperglycemia and morbid outcomes following dissection surgery (5).

We sought to determine how well the ABG/eAG ratio might be used to anticipate postoperative pneumonia following ATAAD surgery.

MATERIAL AND METHOD

This retrospective study comprised patients who underwent ATAAD surgery between January 2016 and January 2022. The study was launched following the

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local ethics committee's clearance, and it was carried out in conformity with the Helsinki Declaration. Within 12 hours of receiving their diagnoses, every patient participating in the study underwent surgery. Patients with preoperative infection, multiple organ failure, and patients who experienced mortality within the first 24 hours following surgery were disqualified from the research. The study contained 124 consecutive patients as a result of exclusion criteria. Information about the patient's preoperative conditions (smoking, demographic features, and laboratory results including neutrophil, lymphocyte, hemoglobin, platelet count, urea, and creatinine), intraoperative procedures (blood transfusions, cardiopulmonary bypass (CPB) time, and surgery type), and postoperative conditions (hospital stay length, intensive care unit (ICU) were recorded. Group 1 patients were those who did not acquire pneumonia following surgery, while Group 2 patients were those who did.

Surgical Technique and Perioperative Blood Glucose Management

All operations were performed under general anesthesia with a median sternotomy approach. Right axillary artery was used for arterial cannulation. Femoral artery cannulation was used in unsuitable patients. In these patients, antegrade cerebral perfusion was performed with a direct approach from the surgical field. Operations were performed in moderate hypothermia. Cardiopulmonary bypass was applied with a roller pump equipped with a membrane oxygenator and arterial line filter (Maquet, Getinge group, Germany).

In all patients, necessary adjustments were made in the crystallized insulin infusion by measuring blood glucose before CPB, at 15-minute intervals during CPB, and at the end of CPB. Hourly insulin requirement was met by dividing the blood glucose level in mg/dl unit by 100. In intensive care follow-ups, treatment attempts were made to keep blood glucose values between 120-180 mg/dl.

Diagnosis of Pneumonia

The diagnosis of pneumonia was made according to the Society of Thoracic Surgeons criteria. Accordingly, findings such as laboratory (positive sputum culture results from transtracheal fluid and/or bronchial washings), radiological findings (pulmonary infiltrates), and fever were included in the evaluation (6).

ABG/aAG ratio

During the patients' stay, peripheral venous blood samples were taken and their blood parameters were assessed. The following formula was used to determine the ABG/eAG value (4).

Admission levels of blood glucose (mg/dl) / [(28.7 x HbA1c %)- 46.7].

Statistical analysis

The SPSS 21.0 program (IBM Statistical Package for the Social Sciences Statistic Inc. Version21.0, Chicago, IL, USA) was used for the statistical analysis. In the case of numerical values having a normal distribution, the Student's t-test was applied. The Mann-Whitney U test was applied in the case of numerical data without normal distribution. The mean (standard deviation) or mean was used to express numerical numbers (minimum-maximum). The chi-square test was used to compare categorical variables. Statistics were judged significant at $P<0.05$. To assess key factors in the univariate study for predicting the development of pneumonia, a multivariate logistic regression analysis was conducted. The area under the curve (AUC) was computed after performing a ROC curve analysis to assess the predictive usefulness of the ABG/eAG ratio for the development of pneumonia.

RESULTS

The study involved 124 patients in total. Group 1 [N = 92, median age = 51 (32 to 80) years] consisted of those who did not acquire postoperative pneumonia, but Group 2 [N = 32, median age = 53 (30 to 77)] did. Age, gender, smoking, blood pressure, previous history of cardiac surgery, ejection fraction, and rates of chronic obstructive pulmonary disease (COPD) did not statistically differ between the two groups (Table 1).

Table 1. Demographic data and preoperative features of the patients

Variables	Group 1 (N= 92)	Group 2 (N= 32)	P value
Age (years)	51 (32- 80)	53 (30- 77)	0.209‡
Male gender, n (%)	65 (70.7%)	21 (65.6%)	0.595*
Hypertension, n (%)	71 (77.2%)	26 (81.3%)	0.630*
COPD, n (%)	9 (9.8%)	5 (15.6%)	0.368*
Diabetes mellitus, n (%)	14 (15.2%)	8 (25%)	0.212*
Current smoker, n (%)	29 (31.5%)	12 (37.5%)	0.536*
Previous cardiac surgery, n (%)	4 (4.3%)	3 (9.4%)	0.289*
Marfan'syndrome, n (%)	3 (3.3%)	2 (6.3%)	0.459*
Duration of pain (hours)	4 (1- 24)	4 (1- 24)	0.196‡
Ejection fraction (%)	50 (30- 65)	45 (30- 65)	0.219‡
Malperfusion, n (%)	6 (6.5%)	3 (9.4%)	0.592*

* Chi-square test, ‡Mann Whitney U test (Data is expressed as median (interquartile range)). Malperfusion: Coroner artery and/or visceral organ artery and/or preoperative neurological sequelae, COPD: Chronic obstructive pulmonary disease

Table 2 displays the patients' perioperative characteristics and preoperative blood values. White blood cell, hemoglobin, platelet, lymphocyte, creatinine, hemoglobin A1c, and C-reactive protein readings were comparable across the two groups. Group 2 had considerably higher ABG and ABG/eAG ratios ($P<0.001$ for two variables). Antegrade cerebral perfusion times, operating periods, and types of surgery did not statistically differ between the

two groups. Total perfusion and ventilation time in Group 2 were substantially longer (P <0.001 for two variables).

To assess the factors that may lead to the development of postoperative pneumonia, logistic regression analysis was used (Table 3). In univariate analysis, it was discovered that the following variables were significantly correlated with the development of postoperative pneumonia: ventilation time (OR [odds ratio]: 1.210, 95% CI [confidence interval]: 1.079-1.690, P<0.001), blood product use (OR: 0.895, 95% CI: 0.790-0.964, P<0.001), total perfusion time (OR: 0.780, 95% CI: 0.550-0.872, P<0.001), ABG (OR: 0.775, 95% CI: 0.554-0.869, P< 0.001), and ABG/eAG ratio (OR: 1.080, 95% CI: 1.016-1.270, P< 0.001).

ABG/eAG ratio and ventilation time were found to be independent predictors of postoperative pneumonia by multivariate analysis [(OR: 0.886, CI 95%: 0.695-0.990, P=0.009) and ventilation time (OR: 1.114, 1.030-1.542, P=0.023)].

To evaluate the ABG/eAG ratio's performance in predicting the emergence of postoperative pneumonia, receiver operating characteristic curve analysis was carried out. The cut-off value of the ABG/eAG ratio was 1.6 (Area under the curve (AUC): 0.776, 95% Confidence interval (CI): 0.686-0.866, P< 0.001, with 78.4% sensitivity and 66.9% specificity) (Figure 1).

Table 2. Preoperative blood parameters and perioperative features of the patients

Variables	Group 1 (N= 92)	Group 2 (N= 32)	P value
White blood Cell (10^3/µL)	10.1 (7.2- 15.7)	9.8 (8.1- 17.3)	0.326‡
Hemoglobin (g/dL)	12.6 (11.8- 15.5)	13.4 (10.6- 16.4)	0.504‡
Platelet (10^3/µL)	185(100- 395)	192 (89- 378)	0.431‡
Neutrophil (10^3/µL)	6.8 (2.7- 11.7)	7 (2.4- 10.6)	0.374‡
Lymphocyte (10^3/µL)	1.7 (0.7- 4.1)	1.5 (0.8- 4.3)	0.198‡
Creatinine, mg/dL	1.2 (0.7- 2.3)	1.1 (0.8- 2.5)	0.119‡
Urea, mg/dL	18 (14- 50)	16 (12- 55)	0.226‡
C Reactive protein, (mg/dL)	10.9 (3.2- 66)	11.3 (2.6- 59)	0.118‡
ABG, mg/dl	124 (99- 258)	166 (128- 339)	<0.001‡
HbA1c, %	5.9 (5.2- 10.1)	6.1 (5.4- 9.7)	0.184‡
eAG, mg/dl	132.6 (122- 147)	129.8 (119- 151)	0.154‡
ABG/eAG	0.96 (0.91- 1.75)	1.84 (1.3- 3.12)	<0.001‡
Total perfusion time, min	129 (110- 249)	134 (120- 295)	<0.001‡
ACP time, min	26 (18- 40)	29 (22- 36)	0.197‡
Operation time, hours	6.2±1.4	6.4±1.3	0.291†
Ventilator time, hours	6 (4- 96)	12 (8- 240)	<0.001
Surgery types, n			0.491*
Ascending aorta replacement	45	17	
Hemiarch replacement	38	10	
Total Arch replacement	9	5	
Concomitant AVR	11	4	0.935*
Concomitant CABG	14	3	0.408*
Packed blood products (units)	6 (4- 9)	10 (5- 15)	<0.001‡
Total ICU stay (days)	3 (2- 18)	6 (4- 34)	<0.001‡
Total hospital stay (days)	7 (6- 28)	10 (8- 60)	<0.001‡

* Chi-square test, ‡Mann Whitney U test, †Student's t-test, ABG: Admission blood glucose, HbA1c: Hemoglobin A1c, eAG: estimated average glucose, ABG/eAG: Admission blood glucose to estimated average glucose ratio, ACP: Antegrade cerebral perfusion, AVR: Aortic valve replacement, CABG: Coronary artery bypass graft

Table 3. Logistic regression analysis to identify predictors of postoperative pneumonia after aortic dissection surgery

	Univariate analysis			Multivariate analysis		
Variables	**P**	**Exp(B) Odds Ratio**	**95% C.I. Lower Upper**	**P**	**Exp(B) Odds Ratio**	**95% C.I. Lower Upper**
Age, years	0.232	1.110	0.850- 1.270	--	--	--
Hypertension, n	0.659	0.690	0.592- 1.090	--	--	--
Ventilation time, hours	<0.001	1.210	1.079- 1.690	0.023	1.114	1.030- 1.542
Blood product use, units	<0.001	0.895	0.790- 0.964	0.109	0.969	0.756-1.135
Total perfusion time, minutes	<0.001	0.780	0.550- 0.872	0.079	1.190	0.938-1.665
ABG, mg/dl	<0.001	0.775	0.554- 0.869	--	--	--
HbA1c, %	0.230	1.166	0.819- 1.259	--	--	--
eAG, mg/dl	0.194	1.044	0.890- 1.154	--	--	--
ABG/eAG	<0.001	1.080	1.016- 1.270	0.009	0.886	0.695- 0.990

ABG: Admission blood glucose, HbA1c: Hemoglobin A1c, eAG: Estimated average glucose, ABG/eAG: Admission blood glucose to estimated average glucose ratio

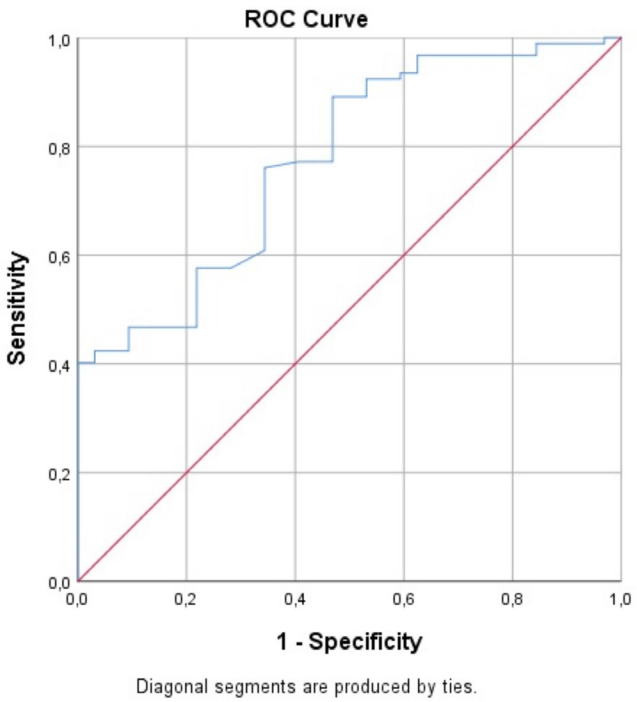

Figure 1. Receiver operating characteristic curve analysis for acute to chronic glycemic ratio to predict the development of postoperative pneumonia

DISCUSSION

Acute Type A aortic dissection is a serious clinical condition that requires urgent surgical intervention. As time passes after the diagnosis, the risk of true lumen collapse increases, so end-organ damage may occur (7). Postoperative pneumonia is a serious condition that can occur after cardiac surgical procedures. This situation is more common after ATTAD surgery, which is an emergency operation. In the present study, we demonstrated that ABG/eAG ratio can be used to predict the risk of pneumonia after ATAAD surgery.

In acute clinical conditions, hyperglycemia also occurs. This has a negative impact on clinical outcomes, regardless of whether patients have diabetes (8). This hyperglycemic condition causes endothelial dysfunction, activates prothrombotic pathways, and raises oxidative stress. As a result, microvascular circulation is also compromised (9). Whether or not someone has DM this circumstance body has a negative impact on the prognosis following acute cardiovascular events (10).

In a study conducted by Lin et al., the effect of high ABG on postoperative results in ATAAD patients was investigated and 734 patients were evaluated retrospectively. The patients were split into two groups with a blood glucose level of 140 mg/dl those with high blood glucose levels and those with normal blood glucose levels. Although there was no difference between the in-hospital mortality rates between the two groups, prolonged ventilation rates were found to be significantly higher in the patient group with hyperglycemia. In addition, in a multivariate analysis investigating the risk factors for prolonged ventilation, hyperglycemia was shown as an independent predictor of prolonged mechanical ventilation in addition to age and body mass index (5). In our investigation, the patient group with pneumonia had significantly higher blood glucose readings upon admission. In a different study, patients who received primary percutaneous coronary intervention with the diagnosis of ST-elevation myocardial infarction showed an association between ABG value and reperfusion failure (11). In another study conducted on orthopedic surgery

patients, an ABG value of over 200mg/dl was found to be associated with deep surgical-site infections (12).

In addition to these unfavorable effects of acute hyperglycemia, people without DM have also shown that HbA1c has worse effects (13). In light of this information, ABG/eAG ratio emerges as an important prognostic marker. The predictive value of the ABG/eAG ratio in patients with acute myocardial infarction was examined in a study by Gao et al. The scientists concluded that ABG/eAG value was more useful than the ABG value in predicting morbid and fatal occurrences (14). In another study by Mondal et al., the prognostic role of the ABG/eAG ratio was investigated in COVID-19 patients with moderate and severe clinical findings. At the end of their study, the usefulness of ABG/eAG value over ABG value in predicting fatal and morbid outcomes was discovered by the authors (15). Chen et al. investigated the clinical significance of the ABG/eAG ratio in patients over 75 years of age with acute myocardial infarction which included 341 patients retrospectively and the ABG/eAG ratio was shown as an important parameter in predicting in-hospital adverse events (16). In our study, we showed the ABG/eAG ratio as an independent predictor in predicting the development of pneumonia after ATAAD surgery.

Postoperative pneumonia is an important infectious pathology that can occur after cardiac surgical operations. This situation not only includes mortal and morbid risks, but also increases the cost of treatment by prolonging hospitalizations. Risk variables affecting the emergence of pneumonia following heart surgery were looked into in a study by Wang et al. in 2021 which included 5,323 patients, postoperative pneumonia was developed in 530 patients. Renal failure, age>60, DM, history of cardiac surgery, prolonged perfusion times, and increased blood transfusion were shown as important parameters affecting the development of pneumonia (17). In another study of 492 ATAAD patients, 34.6% of them developed postoperative pneumonia. Advanced age, COPD, low platelet counts, and increased blood product transfusion were shown as important parameters affecting the development of pneumonia (18). The impact of low platelet counts on the emergence of pneumonia following ATAAD surgery was examined in another study by Yao et al. 268 patients were included in this retrospective investigation, and postoperative pneumonia developed in 36.9% of the patients. In addition to preoperative low platelet counts, long ventilation times, and increased blood product transfusion were found to be significant parameters affecting the development of pneumonia (19). In our study, we found the postoperative pneumonia rate to be 25.8%, and in addition to the ABG/eAG ratio, prolonged perfusion times, prolonged ventilation times, and increased blood product use were significantly correlated with the development of pneumonia.

There are certain limitations to our investigation. The fact that it is a retrospective study with a limited number of patients is the most significant of them.

CONCLUSION

ATAAD is an important cardiovascular disease that requires urgent surgical intervention. Today, it has higher mortality and morbidity compared to other cardiac surgical operations. Pneumonia is an important morbidity that occurs in these patients in the postoperative period. We demonstrated that ABG/eAG ratio, calculated at admission time, is a significant predictor of the development of postoperative pneumonia. Multicenter prospective studies must be used to support our study.

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Conflict of Interest: *The authors declare that they have no competing interest.*

Ethical approval: *The study was approved by the Bursa Yuksek Ihtisas Training and Research Hospital Clinical Research Ethics Committee (2011-KAEK-25 2022/08-23).*

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