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Original Article

Assessment of shock index and glucose/ potassium ratio for early mortality prediction in acute type A aortic dissection

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Abstract

Aim: Acute Type A Dissection (ATAD) is a critical medical condition requiring prompt surgical intervention. The risk of mortality escalates with each hour following diagnosis, highlighting the importance of expeditious treatment. This retrospective cohort study, encompassing 117 ATAD patients over the period from March 2019 to June 2023 at a leading cardiovascular surgery clinic, explores the potential of Shock Index (SI) and Glucose/Potassium Ratio (GPR) as prognostic indicators for early mortality in the preoperative phase.
Material and Methods: Demographic, clinical, and surgical data were gathered from hospital records. Both SI (calculated as heart rate/systolic blood pressure) and GPR (calculated as glucose/potassium) were recorded at admission. Their associations with postoperative mortality and morbidity were examined.
Results: The cohort's mortality rate was at 27.3%, with a noteworthy elevation in GPR observed in the mortality group. While the Shock Index displayed a numerical increase in the mortality group, the disparity did not achieve statistical significance. Optimal GPR cut-off for mortality prediction was identified as 28.7, sensitivity of 0.68 and specificity of 0.64. GPR surpassed SI in predicting mortality, demonstrating an Area Under the Curve (AUC) of 0.67.
Conclusion: In the critical context of ATAD, where time plays a decisive role, the Shock Index may not offer optimal accuracy in predicting early mortality. Conversely, the Glucose/Potassium Ratio emerges as a valuable and expeditious tool for anticipating mortality and prognosis. This study emphasizing the pivotal role of GPR in predicting postoperative outcomes and guiding clinical decision-making.

Keywords: Aortic dissection, shock index, glucose/potassium ratio

INTRODUCTION

Acute Type A Dissection (ATAD) is a life-threatening condition originating in the ascending aorta, demanding urgent surgical management to reduce mortality. Studies indicate that the risk of mortality escalates by 1-2% per hour following diagnosis, critical necessity for prompt surgical intervention in the initial stages of the diagnosis (1).

In the timeframe leading up to surgical intervention, a brief but crucial period is allocated for selecting the surgical technique, strategizing its implementation, and considering various surgical attributes. During this phase, assessing potential postoperative outcomes and mortality risks is crucial for the surgical team. The risk factors for in-hospital mortality, frequently documented in existing literature, primarily include advanced age, left ventricular dysfunction, malperfusion, ischemia in related organs, and cardiac tamponade (2-5).

Various scoring systems have been developed to predict mortality before surgical intervention (6,7). Furthermore, The Penn classification, introduced to define the extent of malperfusion

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and its correlation with mortality (1). Additionally, clinical and laboratory findings have been recommended as potential indicators of mortality (8). Given the narrow preoperative window, identifying a straightforward, rapid, and highly accurate marker for mortality risk is essential.

The Shock Index (SI), calculated as heart rate/systolic blood pressure, serves as a readily calculable parameter, particularly applied in cases of hemorrhagic conditions, trauma, sepsis, pneumonia, pulmonary embolism, and ST-elevation myocardial infarction (MI) (9). Calculated by ratio of heart rate to systolic blood pressure, the normal range falls between 0.5 and 0.7. Nevertheless, it has been demonstrated that mortality rates escalate as the SI value approaches 1 (10).

An elevation in shock index corresponds to a reduction in stroke volume, cardiac index, and left ventricular ejection fraction (LVEF) values (11).

Serum glucose and potassium are well established markers that can be measured quickly and easily via blood gas analysis. In cases of trauma and shock, elevated catecholamine levels increase glucose and decrease potassium, a phenomenon driven by sympathetic activation following the neuroendocrine response to hemorrhage an effect observed in various injuries. A similar response can also manifest in patients with ATAD (12,13). Moreover, severe clinical presentations and higher mortality risk have been linked to post-traumatic hyperglycemia and insulin resistance. Indeed, existing evidence indicates that an elevated glucose-potassium ratio (GPR) serves as a rapid and reliable predictor of morbidity and mortality in patients with subarachnoid hemorrhage, pulmonary embolism, traumatic brain injury, or blunt abdominal trauma (12).

This study aimed to assess the impact of promptly calculable SI and GPR on early mortality in individuals diagnosed with ATAD.

MATERIAL AND METHODS

Study Design

This retrospective cohort study was conducted at a tertiary care hospital and one of the nation's leading cardiovascular surgery clinics. Included 117 patients who underwent surgery for Type A aortic dissection from March 2019 to June 2023. The research was reviewed and approved by the local ethics committee (Ankara Bilkent City Hospital Ethics Committee) with the file number E1-23-3683.

The investigation adhered to the ethical standards outlined in the Declaration of Helsinki. Patient data, including demographic information, comorbidities, medication history, laboratory findings, details of surgical procedures, preoperative echocardiography and CT angiography results, as well as cardiopulmonary bypass and cross-clamp durations, were extracted from hospital records.

Study Enrollments

Under the Stanford classification, ATAD is characterized as emerging from the ascending aorta with symptoms persisting for a maximum of 14 days. Patients presenting with subacute and chronic conditions were not included in this study. Diagnosis of ATAD was established through CT angiography and echocardiography. Vital signs such as blood pressure and heart rate were documented upon admission. Additionally, arterial blood gas analysis and levels of glucose and potassium were recorded upon admission to intensive care.

SI is calculated by heart rate (HR) /systolic blood pressure (SBP). The GPR is determined by glucose (mg/dL) /potassium (mEq/L) ratio.

Outcome Measures

The principal objective was to examine the efficacy of SI and GPR as indicators for postoperative mortality, while the secondary aim focused on their influence on morbidity.

Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics (version 22; Armonk, NY). The comparative outcomes and additional demographic details of the study groups were expressed as ratios for qualitative data, and as means and medians (with range from minimum to maximum) for quantitative data. Data normality was evaluated with the Kolmogorov-Smirnov and Shapiro-Wilk tests. Non-parametric tests were used for variables that were not normally distributed. The Mann-Whitney U test was employed for continuous variables, while chi-square or Fisher's exact test was used for categorical variables. Receiver Operating Characteristic (ROC) curve analysis determined the AUC for GPR and SI, and the Youden index identified optimal cut-off values, sensitivity, and specificity. The threshold for statistical significance was set at $P<0.05$.

RESULTS

Table 1 presents the demographic and clinical data for 117 ATAD patients, including 85 in the survival group and 32 in the mortality group. As shown in Table 2, a demographic comparison between these two groups revealed no statistically significant differences. Coronary artery disease (CAD) was significantly more common in the mortality group ($p=0.006$). The mortality group had significantly lower potassium levels ($p=0.030$), and a higher GPR ($p=0.034$). The shock index was calculated as 0.96±0.33 in the mortality group, whereas it was determined as 0.87±0.25 in the surviving patient group. However, this difference was not statistically significant.

In our research, we observed that patients who underwent surgery sooner (median: 10.5 hours vs. 12.0 hours, $p=0.038$) had a higher survival rate when the time until the operation was taken into consideration.

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Table 1. Demografic and clinical data

Variable		N=117[1]
Age		57.62±11.90
Sex	Female	39 (33%)
	Male	78 (67%)
Hypertension	No	8 (6.8%)
	Yes	109 (93%)
Diabetes	No	69 (59%)
	Yes	48 (41%)
COPD	No	106 (91%)
	Yes	11 (9.4%)
CAD	No	81 (69%)
	Yes	36 (31%)
Admission to operative time(hour)		12.00 (9.00, 20.00)
SBP(mmHg)		120.15±23.05
DBP(mmHg)		70.41±15.54
HR(beat/min)		103.50±15.87
SI		0.90±0.28
Glucose(mg/dL)		115.00 (97.00, 137.00)
Potassium(mEq/L)		4.14±0.62
G/P ratio		26.75 (22.68, 34.57)
Intraoperative Mortality	Yes	8 (6.8%)
	No	109 (93%)
In-hospital Mortality	Yes	24 (21%)
	No	93 (79%)
Overall Mortality		32 (27%)

[1]n (%); Mean±SD; Median (IQR); Median (25%-75%); COPD: chronic obstructive pulmonary diseaese, CAD: coronary artery diseaese, SBP: systolic blood pressure, DBP: diastolic blood pressure, HR: heart rate, SI: shock index, G/P: glucose/potassium

Table 2. Demographic and clinical data according to mortality

Variable		Alive, N=85[1]	Mortality, N=32[1]	p[2]
Age		56.78±12.53	59.88±9.84	0.16
Sex	Female	27 (32%)	12 (38%)	0.56
	Male	58 (68%)	20 (63%)	
Hypertension	No	7 (8.2%)	1 (3.1%)	0.44
	Yes	78 (92%)	31 (97%)	
Diabetes	No	50 (59%)	19 (59%)	0.96
	Yes	35 (41%)	13 (41%)	
COPD	No	75 (88%)	31 (97%)	0.28
	Yes	10 (12%)	1 (3.1%)	
CAD	No	65 (76%)	16 (50%)	**0.006**
	Yes	20 (24%)	16 (50%)	
Admission to operation time (hour)		12.00 (9.00, 21.00)	10.50 (8.00, 16.25)	**0.038**
SBP (mmHg)		120.86±20.18	118.25±29.67	0.65
DBP (mmHg)		69.72±13.82	72.25±19.54	0.50
HR (beat/min)		102.54±16.27	106.03±14.70	0.27
SI		0.87±0.25	0.96±0.33	0.18
Glucose (mg/dL)		110.00 (94.00, 131.00)	124.50 (111.00, 162.50)	0.15
Potassium (mEq/L)		4.22±0.58	3.92±0.67	**0.030**
GPR		25.83 (22.45, 32.16)	32.08 (26.01, 45.24)	**0.034**

[1]Mean±SD; n (%); Median (IQR); Median (25%-75%); [2]Welch Two Sample t-test; Pearson's Chi-squared test; Fisher's exact test; COPD: chronic obstructive pulmonary diseaese, CAD: coronary artery diseaese, SBP: systolic blood pressure, DBP: diastolic blood pressure, HR: heart rate, SI: shock index, GPR: glucose/potassium ratio

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The Area Under the Curve (AUC) for mortality prediction using GPR was determined to be 0.67, as illustrated in Figure 1. Table 3 presents the ROC analysis for predicting mortality assessed four parameters: SI, glucose, potassium, and the GPR. Among these, GPR exhibited the highest area under the curve (AUC=0.67) with an optimal cutpoint of 28.71, yielding a sensitivity of 68.8% and a specificity of 64.0%. In comparison, glucose (cutoff=111 mg/dL) had an AUC of 0.628 with higher sensitivity (78.1%) but lower specificity (51.8%), whereas potassium (cutoff=3.9 mEq/L) showed an AUC of 0.627, balancing a sensitivity of 59.4% and specificity of 61.2%. Although the SI achieved a high specificity of 94.1% at an optimal cutpoint of 1.280, its sensitivity was notably low (25.0%), contributing to the lowest AUC (0.553) among the four markers.

The identified GPR cut-off value for mortality estimation was 28.7, demonstrating a sensitivity of 0.68 and specificity of 0.64.

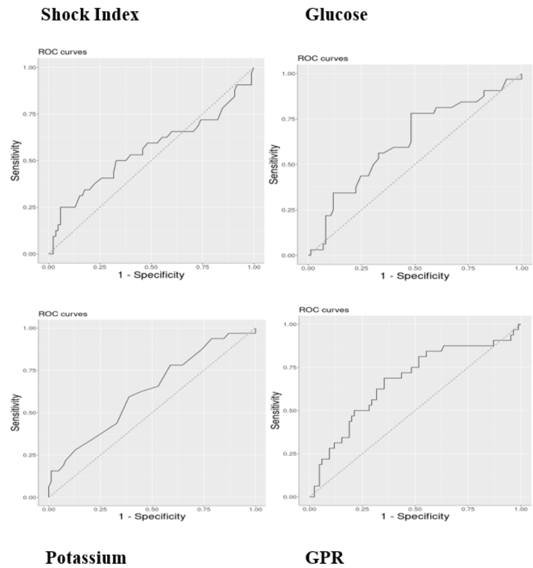

Figure 1. Determination of SI and GPR cut-off values for mortality

Table 3. Optimal cutpoints for GPR and SI in predicting mortality

Predictor	Optimal Cutpoint	Direction	AUC	Sensitivty	Specificity
Shock index	1.280	>=	0.553	0.250	0.941
Glucose (mg/dL)	111	>=	0.628	0.781	0.518
Potassium (mEq/L)	3.9	<=	0.627	0.594	0.612
GPR	28.71	>=	0.67	0.688	0.64

DISCUSSION

ATAD, a condition with a high mortality rate, primarily requires surgical intervention. The time elapsed before surgery is a crucial determinant of mortality (1). Prompt diagnosis leads to early treatment.

Mortality rates associated with ATAD surgery typically fall between 5% and 30%, a range likewise reported in registry studies from the United States, Germany, and Japan (4,14,15). In the International Registry of Acute Aortic Dissection (IRAD) study, early mortality was reported to be within the range of 17-26% (16). In our study, we observed a mortality rate of 27.3%.

Stress or trauma often leads to hyperglycemia, a response that can be amplified by corticosteroids. Additionally, catecholamines and glucagon are known to induce hyperglycemia. While insulin and beta-adrenergic hormones facilitate the transfer of potassium into cells, thereby reducing serum potassium levels (17-19). Various studies have shown that association between major cardiac adverse events (MACE) and dysglycemia or potassium metabolism (20-22). In line with these findings, our results showed that the mortality group had significantly lower potassium levels and a higher Glucose/Potassium Ratio (GPR), underscoring the potential clinical impact of glucose and potassium imbalances in ATAD.

Chen Y. and colleagues was the first to evaluate the relationship between GPR at admission and in-hospital mortality in patients with ATAD (13). Their research showed that higher GPR was an independent risk factor for in-hospital mortality in patients undergoing ATAD surgery. Additional to this study, our focus was on examining both SI and GPR in ATAD patients to assist in predicting post-surgical outcomes and identifying high mortality risks. The significance of SI becomes particularly apparent in urgent scenarios, where it can be calculated at the bedside swiftly without waiting for lab results. Both these markers have been shown to be effective in forecasting mortality and morbidity prior to ATAD surgery. Furthermore, GPR was found to be a stronger predictor of mortality compared to SI ($p<0.05$).

The concept of the SI was introduced by Allgower and Burri in 1967 (23). This index serves as an indicator of hypovolemia severity in hemorrhagic and infectious conditions (24). Presently, the SI is employed as a marker for urgent and prioritized diagnosis or treatment in critically ill patients (25).

In Type A aortic dissection, patients frequently present to the intensive care unit with tachycardia and hypertension. Our study suggests that the inability of the SI to accurately predict mortality and prognosis in ATAD patients is attributable to this clinical presentation. Notably, in ATAD patients, tachycardia and hypotension are often observed in scenarios involving rupture or cardiac tamponade, where the prognostic significance of the SI may become more apparent. Particularly in these instances where the SI is elevated, a corresponding increase in mortality

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is observed. In our study, despite a higher SI in the mortality group, no statistically significant difference was observed.

In the research of individuals with isolated blunt thoracoabdominal trauma, Turan et al. identified the GPR as an effective and rapid predictor of mortality (12). Similarly, in our investigation, GPR proved to be a swift and reliable method for predicting mortality in patients with ATAD, demonstrating a cutoff value of 28.7, with a sensitivity of 0.68 and specificity of 0.64. The AUC for mortality prediction using GPR was 0.67.

Blood glucose and potassium were routinely tested clinically and easily obtained nearly all patients. GPR may help to predict the prognosis of ATAD patients in first admission. GPR may play a certain role in predicting the postoperative decision-making process of physicians for their patients.

Nonetheless, our study has limitations. It is a single-center, retrospective analysis that did not exclude patients on medications affecting the glucose-potassium balance or those with diabetes. Further large-scale, prospective studies are needed to confirm the role of GPR in ATAD risk stratification and refine its clinical applications.

CONCLUSION

ATAD is an extremely lethal condition where surgical intervention is the primary treatment. Prompt diagnosis and early surgical action are critical in determining patient survival. This research indicates that while the SI is commonly employed to forecast mortality in various trauma and shock situations, it is not effective for patients with ATAD. Conversely, the study demonstrates that the GPR is a rapid and dependable tool for anticipating mortality and prognosis in ATAD cases.

Conflict of Interests: The authors declare that there are no conflict of interests.

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Ethics Committee Approval: The research was reviewed and approved by the local ethics committee (Ankara Bilkent City Hospital Ethics Committee) with the file number E1-23-3683.

Patient Informed Consent: Not necessary for this manuscript.

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