

# Venous glucose, serum lactate and base deficit as biochemical predictors of mortality in patients with polytrauma

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## ABSTRACT

**BACKGROUND:** The trauma and injury severity score (TRISS) and Acute Physiology and Chronic Health Evaluation IV (APACHE IV) are accurate but complex. This study aimed to compare venous glucose, levels of serum lactate, and base deficit in polytraumatized patients as simple parameters to predict the mortality in these patients versus (TRISS) and (APACHE IV).

**METHODS:** This was a comparative cross-sectional study of 282 patients with polytrauma presented to the Emergency Department (ED).

**RESULTS:** The best cut off value of TRISS probability of survival score for prediction of mortality among poly-traumatized patients was  $\leq 90$ . APACHE IV demonstrated 67% sensitivity and 95% specificity at 95% CI at cut off point 99. The best cutoff value of Random Blood Sugar was  $> 140$  mg/dl, with 89% sensitivity, 49% specificity; base deficit was less than  $-5.6$  with 64% sensitivity, 93% specificity; lactate was  $> 2.6$  mmol/L with 92%, sensitivity, 42% specificity.

**CONCLUSION:** Venous glucose, serum lactate and base deficit are easy and rapid biochemical predictors of mortality in patients with polytrauma. These predictors could be used as TRISS and APACHE IV in predicting mortality.

**Key words:** APACHE IV; base deficit; lactate; polytrauma; TRISS; venous glucose.

## INTRODUCTION

Polytrauma is defined as injury to several physical regions or organ systems, where at least one injury or the combination of several injuries are life threatening with the severity of injury being equal or  $> 16$  on the scale of the Injury Severity Score (ISS). Prediction of mortality in trauma patients is an important part of trauma care. Prognosis of polytrauma depends on several factors with a definitive influence. [1] The trauma and injury severity score (TRISS) and Acute Physiology and Chronic Health Evaluation IV (APACHE IV) are used commonly to predict injury severity and risk of

mortality. Although it is regarded as the international standard in trauma scoring, it has complex calculating and incorporates the Glasgow Coma Scale (GCS) for neurological evaluation. Up to 30% of patients with trauma are intubated and sedated upon arrival to the Emergency Department. [2] Regardless of the accuracy of trauma scores, is based on an anatomical description of every injury and cannot be assigned to the patients until a full diagnostic procedure has been performed. [3]

Many studies have revealed alteration in glucose metabolism in trauma and proportional relation of its high level to the degree of injury. [4] In addition, lactate levels reflect the anaerobic metabolism caused by tissue hypo-perfusion in a shocked patient. [5] Moreover, base deficit is considered a reliable physiologic parameter that relates to actual tissue perfusion in hypovolemic shock and indicates resuscitation requirements in critically injured patients. [6,7]

Therefore, this study was conducted to compare between alterations in easy and rapid predictors as glucose level, base deficit and lactate and difficult and slow predictors as TRISS and APACHE IV. So, it could be considered an early and easy rapid predictor of mortality.

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## Hypothesis

[Primary] Alterations in admission glucose, lactate levels and base deficit can be used as a predictors of mortality in polytraumatized patients.

[Secondary] These predictors are early, rapid and easy methods for mortality prediction.

## MATERIALS AND METHODS

### Study Design and Setting

This was a comparative cross-sectional study that enrolled all adult polytraumatized patients with severity of injury being equal or above 16 on the scale of the Injury Severity Score (ISS). It was conducted at department of Emergency, at the Suez Canal university hospital, Ismailia, Egypt.

The study received an approval from the Institutional Research Review Board Ethical Committee of the Suez Canal University, Faculty of medicine, Ismailia, Egypt and conducted in accordance with the guidelines of the Helsinki Declaration, and performed after obtaining the informed consent from all relatives of participants during the period of January 2012 to January 2013.

### Study Population

Each enrolled patient was subject to full history (from patient or relative) including: (1) Patient personal data: Age, gender, Occupation and residence. (2) Time of injury and admission. (3) Mechanism and type of injury according to CDC classification. Furthermore, the patient was examined clinically (vital sign, Glasgow Coma Scale and patients' anatomical injury coded according to the Abbreviated Injury Scale (AIS) to calculate TRISS). Pregnant patients and those with psychiatric illnesses were excluded.

The laboratory measurements were as follows: [hemoglobin (Hb) and hematocrit >10, base deficit <6 mmol/L, venous glu-

cose >140 and Serum Lactate >2 mmol/L]. Then, TRISS was recalculated for patients admitted to the surgical ward within 24 hours to reach final TRISS. TRISS and APACHE IV patients admitted to the intensive care unit within the first 24 hours and the most worse clinical and laboratory value was taken.

### Statistical Analysis

Statistical analysis was performed using the SPSS software version 16 (SPSS Inc, Chicago, IL, USA). Quantitative data were expressed as mean±standard deviation (SD) while qualitative data were expressed as frequency and percentages. Qualitative categorical variables were compared using chi-square test. Quantitative continuous data were compared using the nonparametric Mann–Whitney test instead of the Student t-test as normal distribution of the data could not be assumed. Kruskal–Wallis test was used to assess the independent effects of multiple categorical variables as a normal distribution of the data could not be assumed. A probability value (p value) <0.05 was considered statistically significant.

## RESULTS

This study enrolled two hundred and eighty-two patients with polytrauma presented to the Department of Emergency. In this study, two hundred and forty-three (86.17%) survived and thirty-nine (13.83%) died. Mean of RBS, serum lactate and base deficit were 159.2±63.6; 3.2±1.37 and -3.34±2.38, respectively (Table 1). TRISS probability of survival had significant negative correlation with all other predictors that was strongest with APACHE IV (-0.8) and only positive correlation with base deficit (0.7). APACHE IV had significant moderate correlation with all laboratory predictors. All laboratory predictors (RBS, serum lactate, base deficit) had weak/moderate significant positive correlation with each others (Tables 2, 3). The best cutoff values of all suggested predictors with predictive characteristics, as we found that the sensitivity of our study was at the highest level. The most sensitive predictors were RBS and serum lactate (sensitivity, 89 and 92% respectively), while the most specific predictors were TRISS score,

**Table 1.** Data of studied patients

Variables	N	Range	Mean±SD
All patients			
Laboratory predictors			
RBS	282	70–407	159.2±63.6
Serum lactate	282	1.3–8	3.2±1.37
Base deficit	282	-1–13	-3.34±2.38
Mortality predictor scores			
TRISS probability of survival	282	6.2–98.7	90.38±18.66
APACHE IV	87	32–137	77.45±27.37

N.B: APACHE IV score was estimated only for patients admitted to ICU (n=87patients). SD: Standard deviation; RBS: Random blood sugar; TRISS: The trauma and injury severity score; APACHE IV: Acute Physiology and Chronic Health Evaluation IV.

**Table 2.** Dead patients versus survived patients according to laboratory predictors and mortality predictor scores

Variables	Died (n=39)		Survived (n=243)		t-test
	Range	Mean±SD	Range	Mean±SD	
All patients					
Laboratory predictors					
Random blood sugar	80–325	211.8±65.6	70–407	150.79±59.2	0.001*
Serum lactate	2–7	4.47±1.3	1.3–8	2.99±1.26	0.001*
Base deficit	-1–13	-6.49±-3.5	-1–11	-2.8±-1.67	0.001*
Mortality predictor scores					
TRISS probability of survival	6.2–97	61.93±37.3	61.2–98.7	94.95±5.85	0.001*
APACHE IV	45–137	99.1±31.03	32–100	67.7±18.86	0.001*

\*Statistically significant difference. SD: Standard deviation; TRISS: The trauma and injury severity score; APACHE IV: Acute Physiology and Chronic Health Evaluation IV.

**Table 3.** Correlation between different predictors of mortality among survived and died patients

	TRISS probability of survival		APACHE IV		Random blood sugar		Serum lactate		Base deficit	
	Survived	Died	Survived	Died	Survived	Died	Survived	Died	Survived	Died
	TRISS probability of survival	–	–	-0.7*	-0.6*	0.08†	-0.6*	-0.3*	-0.1†	0.4*
APACHE IV	-0.7*	-0.6*	–	–	0.2†	0.3†	-0.3*	0.4*	-0.1	-0.5*
Random blood sugar	0.08†	-0.6*	0.2†	0.3†	–	–	0.1†	0.04†	-0.02	-0.5*
Serum lactate	-0.3*	-0.1†	-0.3*	0.4*	0.1†	0.04†	–	–	-0.3*	-0.3†
Base deficit	0.4*	0.7*	-0.1†	-0.5*	-0.02†	-0.5*	-0.3*	-0.3†	–	–

†Statistically non-significant difference. \*Statistically significant difference. TRISS: The trauma and injury severity score; APACHE IV: Acute Physiology and Chronic Health Evaluation IV.

**Table 4.** Predictive characteristics of all evaluated predictors

	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)	Accuracy (%)
TRISS ≤90	77	89	52.6	96	87
APACHE IV (>99)	67	95	85.7	86.4	86
Random blood sugar (>140)	89	49	22.2	96.8	46
Serum lactate (>2.6)	92	42	20.3	97.1	43
Base deficit (<-5.6)	64	93	59.5	94.2	89

TRISS: The trauma and injury severity score; APACHE IV: Acute Physiology and Chronic Health Evaluation IV.

APACHE IV score and base deficit (specificity 89%, 95% and 93%, respectively) (Table 4).

## DISCUSSION

Trauma scoring systems are commonly used for prognosis and determining the severity of a patient's condition in the early stage of treatment. TRISS and APACHE IV are considered from the most widely used trauma scoring systems (TSSs), and it strongly predicts the probability of survival.<sup>[2,8,9]</sup>

Several studies indicate that trauma-related deaths are usually divided into three groups. Group I (50%) enrolls those who die at the scene (usually patients with major head trauma or severe vascular injury). Group II (30%) enrolls those who are admitted to the hospital and die within the first several hours, a period termed the “golden hour.” These injuries often include major head, thorax, and abdominal trauma. Group III (20%) consists of patients who die at a later time, for example in an ICU. The deaths in this group are typically due to

sepsis or multi-organ failure.<sup>[10]</sup> The mortality of patients in Groups 2 and 3 could be prevented with fast and accurate treatment methods.

TRISS and APACHE IV are widely accepted TSSs, and their calculation requires that all examinations and workups are performed and that injuries in anatomic locations are noted in a detailed manner. The accurate determination of the seriousness of the condition on the part of patient is only possible through accurate identification of the injury. Both methods require time.

Therefore, this study was conducted to compare between alterations in easy and rapid predictors as glucose level, base deficit and lactate and difficult and slow predictors as TRISS and APACHE IV. So, it could be considered an early and easy rapid predictor of mortality.

This study showed that the best cut-off value of TRISS probability of survival score for the prediction of mortality among poly-traumatized patients was  $\leq 90$ , with 77% sensitivity and 89% specificity. Using area under the ROC curve (0.89) at (95%CI), positive predictive value was 52.6% and negative predictive value was 96%. This agreed with the study of Aydin et al., who had found that the ideal cut-off value of TRISS for predicting mortality was 90 (AUC: 0.934,  $p < 0.001$ , sensitivity: 83.2%, specificity: 87.9%),<sup>[11]</sup> and with another study, trying to apply TRISS methodology in Spanish trauma intensive care unit, which had found that the TRISS total accuracy was 0.88 (sensitivity was 0.67; specificity was 0.93; area under the ROC curve was  $0.85 \pm 0.03$ ).<sup>[12]</sup>

In our results, APACHE IV demonstrated 67% sensitivity and 95% specificity at 95% CI, positive predictive value was 85.7% and negative predictive value was 86.4%, at cut off point 99. This agrees with a study done in high graduate educational and training hospital in Turkey, where they have selected a cut-off value of  $88.7 \pm 17.6$  (which is close to ours) sensitivity was 94.7% and specificity was 94.4%.<sup>[13]</sup>

In our study, the best cut-off value of Random Blood Sugar (RBS) for prediction of mortality among poly-traumatized patients was more than 140 mg/dl, with 89% sensitivity, 49% specificity, positive predictive value was 22.2% and negative predictive value was 96.8. Th, low cut-off point was used to increase the sensitivity of our results. Our cut-off value also agrees with Gore D et al., who have retrospectively studied 58 pediatric burn patients with  $>60\%$  total body surface area (TBSA) burns. They have divided patients into a poor glucose control group (defined as plasma glucose values  $>140$  mg/dl) and an adequate glucose control group (values  $<140$  mg/dl). They have found that hyperglycemic patients have a greater incidence of positive blood cultures, a decreased percentage of skin graft "take," and an increased mortality.<sup>[14]</sup> In another study, at a cut-off point 200 mg/dl, the glucose level has 93.2% specificity and 37.9% sensitivity, the positive predictive value

(PPV) is 13.4% and the negative predictive value (NPV) is higher than expected at 98.2%.<sup>[15]</sup>

The best cut-off value of base deficit for prediction of mortality among poly-traumatized patients was less than -5.6 with 64% sensitivity, 93% specificity, Positive predictive value was 59.5% and negative predictive value was 94.2%. This agrees with one study for base deficit in abdominal trauma patients. They used a cut-off point of -6 and obtained 88.2% sensitivity and 95.2% specificity, with positive and negative predictive values of 79% and 97.5%, respectively.<sup>[16]</sup>

It also agrees with the results of one study on the basis of 1,810 multiply injured traumas. Potential predictors for transfusion requirements, including BD and lactate, have been identified via logistic regression. Admission BD has been proven to be one of the best predictors for mortality. A BD level of -6 mmol/L has been identified as an important cutoff point for mortality.<sup>[17,18]</sup>

In our results, lactate cut-off point was  $>2.6$  mmol/L with 92% sensitivity, 42% specificity; the positive predictive value was low as 20.3% and the negative predictive value was very high as 97.1%. In agreement with other studies, abnormal serum lactate ( $>2$ ) was associated with 62.6% sensitivity, and 50.6% specificity; PPV was 34.9% and NPV was 76.2%.<sup>[19]</sup>

Sammour T et al. have estimated that abnormal lactate is defined as  $>2$  mmol/L. In their study, 13.0% of the patients with a lactate  $>2$  mmol/L died when compared to 2.7% of the patients with a lactate  $<2.0$  mmol/L. At this threshold, an abnormal lactate was 56.8% specific and 81.0% sensitive for death. PPV was once again low at 13.0% and NPV was suitably high at 97.4%.<sup>[20]</sup>

The highest risk of mortality was found using a cut-off value of 90 in TRISS score while with laboratory parameters, the highest risk of mortality was with serum lactate  $>2.6$ . The three parameters in predicting mortality in poly-traumatized patients were accurate, early and easy rapid predictors of mortality.

## Conclusion

Venous glucose, serum lactate and base deficit are easy and rapid biochemical predictors of mortality in patients with polytrauma. These predictors could be used as TRISS and APACHE IV in predicting the mortality.

Conflict of interest: None declared.

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## ORIJİNAL ÇALIŞMA - ÖZET

### Çoklu travmalı hastalarda biyokimyasal mortalite prediktörü olarak venöz glukoz, serum laktat ve baz açığı

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**AMAÇ:** Travma ve yaralanma şiddeti skoru (TRISS) ve Akut Fizyoloji ve Kronik Sağlık Değerlendirmesi IV (APACHE IV) kesin olmakla birlikte karmaşıktır. Bu çalışmanın amacı, TRISS ve APACHE IV'e karşı çoklu travması olan hastalarda mortaliteyi öngörmek amacıyla basit parametreler olan venöz glukozu, serum laktat seviyelerini ve baz açığını karşılaştırmaktır.

**GEREÇ VE YÖNTEM:** Acil Servis Bölümü'ne başvuran 282 çoklu travmalı hastanın karşılaştırmalı bir enine kesit çalışması yürütüldü.

**BULGULAR:** Çoklu travmalı hastalar içerisinde mortalite tahmininde TRISS muhtemel sağ kalım skoru için en iyi kesim değeri  $\leq 90$ 'dır. %95 GA'da ve kesim değeri 99'da APACHE IV %67 sensitivite ve %95 spesifite göstermiştir. %89 sensitivite ve %49 spesifite ile random kan şekeri için en iyi kesim değeri  $> 140$  mg/dl idi. %64 sensitivite ve %93 spesifite ile baz açığının en iyi kesim değeri  $-5.6$  idi. %92 sensitivite ve %42 spesifite ile laktat için en iyi kesim değeri  $> 2.6$  mmol/L idi.

**TARTIŞMA:** Çoklu-travmalı hastalarda venöz glukoz, serum laktat ve baz açığı kolay ve hızlı biyokimyasal mortalite prediktörleridir. Mortaliteyi öngörmek için bu prediktörler de TRISS ve APACHE IV gibi kullanılabilir.

**Anahtar sözcükler:** APACHE IV; baz açığı; çoklu-travma; TRISS; venöz glukoz.

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