ORIGINAL ARTICLE

Correlation of the association of serum lactate, random blood sugar, and revised trauma score as predictors of outcome in hemodynamically unstable abdominal emergencies

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Abstract

Background: Elevated levels of serum lactate and glucose during resuscitation have been demonstrated to be predictors of morbidity and mortality in hemodynamically unstable patients with surgical abdominal conditions. However, the rate of return to normal levels of both lactate and blood glucose may be better predictors of mortality and morbidity. The aims of this study are: (I) To determine the pattern of serum lactate and glucose changes in patients with surgical abdominal conditions requiring resuscitation within 48 hours of presentation. (II) To correlate the predictive capability of these two independent parameters. (III) To correlate the predictive values of these parameters with the revised trauma score (RTS).
Patients and Method: This is a prospective observational study conducted over three months. The patients admitted by the general surgery division requiring resuscitation from shock was included in this study. Resuscitation was carried out with crystalloids. The estimation of serum lactate and glucose levels was done at presentation (0 hours), 12, 24 and 48 hours after admission. The revised trauma score (RTS) was calculated for each patient at presentation and at 12, 24 and 48 hours subsequently. The patients were followed up four weeks or when death occurred within four weeks of presentation.
Results: Forty four patients were recruited in the study. There were seven mortalities. The mean serum levels of Plasma glucose and lactate of all the patients were elevated at presentation in the emergency department.
Conclusion: Survival was better with a return to normal serum lactate within 12 hours. On the other hand the random plasma glucose (RPG) levels may not be useful in prognosticating patients. However a combination of serum lactate, RTS (at 24 and 48 hours) and RPG at 48 hours may improve predictive parameters in trauma related cases.

Key words: Glucose, lactate, mortality, trauma

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Introduction

Trauma and sepsis elicit arrays of metabolic responses aimed at ensuring the restoration of adequate perfusion

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and oxygenation which ultimately lead to the release of energy and substrates for organs and systems which are essential for survival. These metabolic responses consist of enhanced proteolysis, neoglucogenesis, and resistance of peripheral tissues to insulin with resultant elevation of serum glucose. Resuscitation attenuates and attempts a reversal of the physiologic and metabolic changes associated with consequent hypoperfusion in septicemia and trauma.

Clinical shock is often associated with tachycardia, hypotension with concomitant tissue hypoxia due to hypoperfusion producing increased serum lactic acid and base excess,[1] consequent on anaerobic metabolism. Adequate resuscitation in surgical conditions is traditionally assessed by normalization of the patients' vital signs such as the pulse, blood pressure, respiratory rate, and at times the patient's sensorium. The goal of resuscitation in these patients is the restoration of normal intravascular volume and maintenance of adequate tissue perfusion. However, despite the apparent normalization of these parameters due to some subtle compensatory changes, lactate levels remain elevated in some hemodynamically stable patients due to the phenomenon of occult hypoperfusion,[2,3] or compensated shock. The optimal guide to adequate resuscitation should rapidly assess resolution of tissue hypoxia and probably predict the outcome of the event. Such an ideal guide may be considered as a predictor of survival. Elevated levels of serum lactate and glucose have been demonstrated to be predictors of morbidity and mortality.[4-6] However, the rate of return to normal levels of both lactate and blood glucose may be better predictors of mortality and morbidity.

The objectives of this study are:

- To determine the pattern of serum lactate and glucose changes in patients with surgical abdominal conditions requiring resuscitation within 48 h of presentation
- To correlate the predictive capability of these two independent parameters
- To correlate the predictive values of these parameters with the revised trauma score (RTS).

Patients and Methods

This was a prospective observational study conducted over 3 months. All patients admitted through the Emergency Department or the surgical outpatient clinics by the general surgery division for resuscitation from shock due to abdominal trauma, peritonitis, and other acute abdominal conditions were included in this study. All patients below 18 years were excluded from the study.

For each patient, the biodata was obtained; the Glasgow Coma Score and vital signs (pulse, blood pressure, and respiratory rate) were recorded at presentation. At presentation, all the patients had large bore cannula for venous access, a nasogastric tube for gastric decompression, and a urinary catheter for monitoring urine output. Resuscitation was carried out or supervised by senior residents in surgery or the Emergency Department. The patients' vital signs and urinary output were recorded hourly. Fluid resuscitation is done with an infusion of normal saline as rapidly as required with the goal of attaining adequate tissue perfusion characterized by systolic blood pressure between 100 mmHg and 140 mmHg and an hourly urine output above 50 ml/h. Serum samples were obtained for estimation of lactate and glucose levels at presentation (0 h), 12, 24, and 48 h after admission. For this study, the i-Special Tertiary Admissions Test system test for lactate which measures L-lactate concentration in the plasma of venous blood samples collected in sodium heparin "Vacutainer" tubes was used. This has a detection range from 0.3 mmol/L to 20 mmol/L and provides results in 60 s. The enzyme lactate oxidase, immobilized in the lactate biosensor, selectively converts lactate to pyruvate and hydrogen peroxide (H_2O_2). The liberated H_2O_2 is oxidized at a platinum electrode to produce a current which is proportional to the sample's lactate concentration.

Lactate oxidase

$$\text{L-Lactate} + O_2 \longrightarrow \text{Pyruvate} + H_2O_2$$

Platinum electrode

$$H_2O_2 \longrightarrow 2H+ + O_2 + 2e^-$$

The serum sugar was determined with the use of a glucometer. The RTS was calculated for each patient at presentation and at 12, 24, and 48 h subsequently. The probability of survival was calculated for each patient. The patients were followed up 4 weeks or to the time of death when mortality occurred within 4 weeks of presentation. The pattern of serum lactate and glucose were compared with the RTS as predictors of survival.

Results

The complete data were available for forty-four persons consisting of thirty-one males and thirteen females (M: F ratio

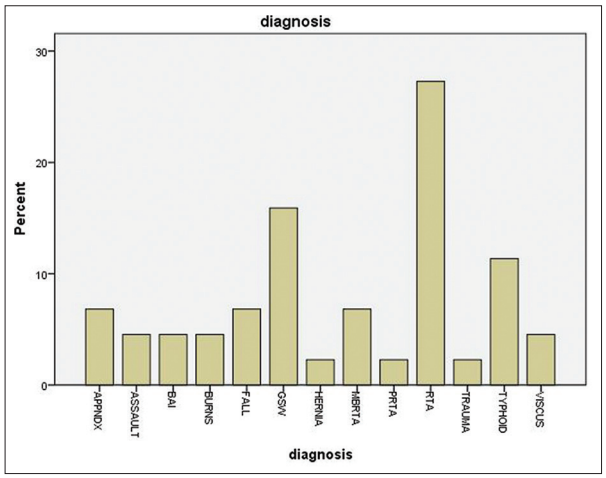

Figure 1: Distribution of diagnoses

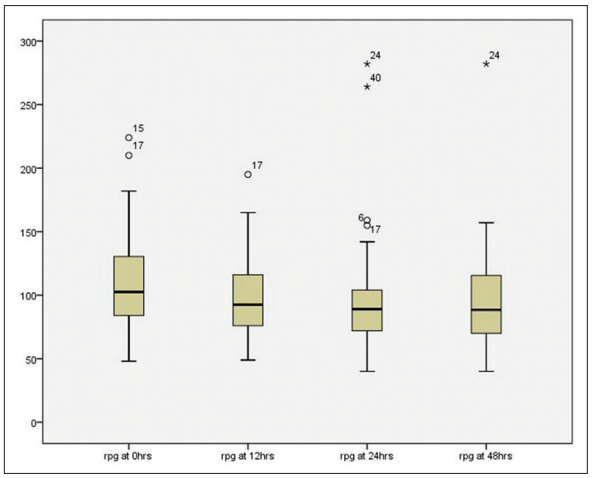

Figure 2: Random plasma glucose mg/dl

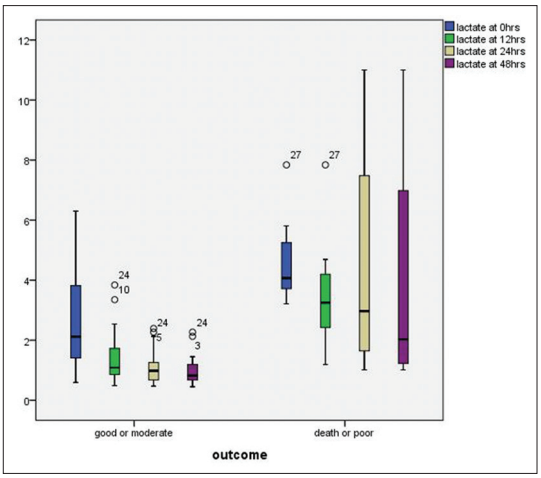

Figure 3: Serum lactate in mmol/L

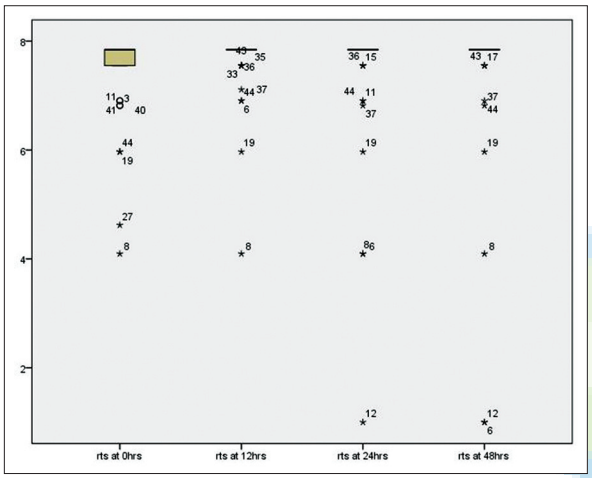

Figure 4: Boxplot - revised trauma score mean revised trauma score at admission was 7.455 (standard deviation = 0.83, 44). It rose to 7.620 (standard deviation = 0.65, 44) after 12 h but then dipped to 7.338 (standard deviation = 1.84, 44) after 48 h of admission. The median remained unchanged (7.841, MAD = 0.2–0.5, 44) across all four sample points

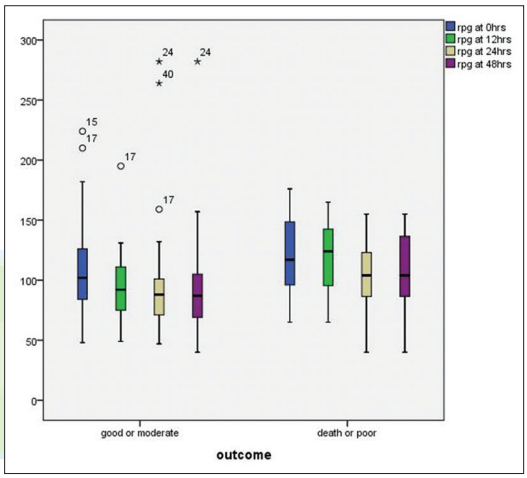

Figure 5: Grouped boxplot - RPG* outcome patients were assigned to one of two groups based on outcome; good - moderate (Group 1); poor - died (Group 2). Sample means in both groups were then compared. Mean RPG was consistently higher for Group 2 (rpg0 = 121, standard deviation = 40.10, 7) vs. Group 1 (rpg0 = 109.73, standard deviation = 40.57, 37) and (rpg3 = 106.43, standard deviation = 39.69, 7) versus (rpg3 = 94.68, standard deviation = 41.96, 37)

of 2.4:1). The patients were divided into two groups (Group 1; good: Group 2; poor outcome; or death). The ages ranged from 18 years to 65 years. Seventy-three percent of these patients were between the ages of 18 and 40 years while others were in the fifth decade of life. Two patients were 65 years of age. Eleven patients (25%) had nontraumatic acute abdomen while 33 (75%) were trauma-related admissions [Figure 1]. There were 7 (15.9%) mortalities within the follow-up period.

The mean random plasma glucose level on admission was 111.52 mg/dl (standard deviation [SD] ±40.24). This reduced to 98.68 mg/dl (SD ± 29.21) after 12 h and steadily dropped further to 96.55 mg/dl (SD ± 41.39) after 48 h of admission [Figure 2].

The mean serum lactate level at admission was 3.04 mmol/L (SD ± 1.77). The mean serum lactate dropped progressively over 48 h. It reduced progressively to 1.73 (SD ± 1.37) mmol/L at 12 h and steadily to 1.50 (SD ± 2.16) mmol/L after 48 h of admission. The mean serum lactate level was consistently higher in patients with poor outcome [Figure 3].

The mean RTS at admission was 7.455 (SD ± 0.83). This increased marginally to 7.620 (SD ± 0.65) after 12 h but dipped to 7.338 (SD ± 1.84) after 48 h of admission. The median RTS remained unchanged (7.841) [Figure 4].

A review of the clinical outcome within the period revealed persistently higher RPG in patients who died compared to the survivors [Figure 5]. The mean RPG was consistently higher for the nonsurvivors than in the survivors at all

Step	Entered	Wilks' Lambda							
		Statistic	df1	df2	df3	Exact F			
						Statistic	df1	df2	Sig.
1	rts at 24hrs	.472	1	1	42.000	46.892	1	42.000	.000
2	lactate at 12hrs	.285	2	1	42.000	51.535	2	41.000	.000
3	rts at 12hrs	.160	3	1	42.000	70.250	3	40.000	.000
4	rpg at 48hrs	.145	4	1	42.000	57.646	4	39.000	.000

Figure 6: Discriminatory analysis

four test points ($P = 0.008$).Similarly, the mean serum lactate was also consistently higher at all four points in patients who died compared to survivors. (lactate 0 = 4.72, SD ± 1.62) version Group 1 (lactate 0 = 2.72, SD ± 1.63) and (lactate 3 = 4.35, SD ± 4.59) version (lactate 3 = 0.96, SD ± 0.41) ($P < 0.001$). The RTS scores were similarly lower in the patients who died compared to the survivors.

Fisher's exact tests showed no association between the patients' age, sex, or clinical diagnosis and patient outcome. There was also no statistically significant relationship between RPG levels and the patient outcome, but the RTS-score was strongly associated with patients' outcome. A stepwise discrimination analysis of the three analytical parameters (RTS, lactate, and RPG) revealed a 100% predictive accuracy (hit ratio) of the discriminant function [Figure 6].

Discussion

In hemodynamically unstable patients, there is a need for rapid assessment of resuscitation and early detection of occult hypoperfusion. Traditional parameters of adequate resuscitation are not accurate indicators of satisfactory tissue perfusion. The search for an appropriate indicator of optimal resuscitation in hemodynamically unstable patients persists. Lactate clearance has been used as an index of resuscitation. The RTS is based on the use of physiologic variables (vital signs, Glasgow Coma Scale) which often predict the severity of physiological insult but may not envisage the need for further fluid resuscitation. Its increasing values; however, reflect improved physiological states.

Lactate is a byproduct of anaerobic metabolism which increases in tissue hypoperfusion. The increase in serum lactate level is not only due to increased production by hypoxic tissues but also a reduced clearance by the liver and kidney. Elevated serum lactate levels due to tissue hypoxia and hypoperfusion correlate with the severity of shock in both trauma and sepsis.[7] The serum lactate level at presentation is an indicator of the severity of hypoperfusion, but it is not an accurate predictor of the outcome of resuscitation.[8] The of serum lactate clearance over 12–24 h has been shown to be a better predictor of the patient's outcome.[9] Mortality rates ranging from 38% to 49% in patients with initial levels of serum lactate above 4 mmol/L have been demonstrated in both nonshock and shock patients, respectively.[10] In another study, patients whose lactate levels normalized (lactate level <2 mmol/L) in 24 h had a calculated mortality risk of 3.9%. This risk rose sharply to 42.5% with persistently elevated lactate levels (>4 mmol/L) at 48 h.[6]

Similarly, persistent hyperglycemia is a predictor of poor outcome in critically ill patients.[4] This study demonstrates that lactate clearance provides additional predictive information to the initial serum lactate levels at the presentation in surgical abdominal conditions. Concurrently, the mean random blood glucose (RBG) was also elevated while the RTS was initially low at presentation. Following resuscitation, there was a reduction in serum lactate levels, as well as RBG levels with a transient increase in RTS. However, this reduction in serum lactate and RBG levels was not sustained in the subset of patients (Group 2) who died. A closer evaluation of lactate and RBG parameters in Group 2 patients revealed not only grossly higher levels of lactate at presentation but also the rate of lactate clearance was also slower with higher values at 12, 24, and 48 h, respectively, with $P = 0.05$ and 0.034 at 12 and 24 h, respectively [Figure 3]. An elevated level of serum lactate at presentation is a tool for risk stratification[11] but does not reflect the adequacy of resuscitation. The rate of lactate clearance (return to normal levels) is an indicator of adequate resuscitation, and this reduces unnecessary infusion of crystalloids and the risk of dilution coagulopathy. The initial fall in the

serum lactate level within the first 12 h appears to be a major determinant in the probability of survival. Regardless of the primary cause of hypoperfusion, i.e. trauma or sepsis-related, serum lactate reduction during the first 24 h of admission is associated with improved outcome.[12,13] Several arguments suggest various times for estimation of serum lactate levels while resuscitating ranging from 2 h and above. A 12 h interval has been found to be predictive in our environment considering the cost and logistics in developing countries like ours. There is a need for future studies of higher volume to analyze subtle differences between trauma-related and septic conditions.

The RTS is a good predictor of the physiological insult. The RTS values were statistically significantly higher in patients in Group 2 at 24 and 48 h ($P = 0.029$ and 0.031), respectively. Although the mean RPG was higher in Group 2 patients, there was no statistically significant relationship to the outcome. A stepwise discriminant function analysis was performed to predict whether a patient had a good or a poor outcome. The predictor variables included in the test were rpg0, rpg1, rpg2, rpg3, lact0, lact1, lact2, lact3, rts0, rts1, rts2, and rts3. 4 of the 12 predictor variables differentiated between Group 1 and Group 2, all statistically significant with $P < 0.001$ [Figure 6]. Discrimination analysis of the three analytical parameters (RTS, Lactate, and RPG) revealed a 100% predictive accuracy (hit ratio) of the discriminant function.

Conclusion

Serum lactate levels measured at admission is a prognostic marker in hemodynamically unstable surgical abdominal conditions, but the lactate clearance provides additional predictive information to initial blood lactate levels. Serum lactate clearance after 12 h on admission is a useful tool which predicts survivors from nonsurvivors with the surgical (trauma- or nontrauma-related) abdomen. This is demonstrated in both trauma- and nontrauma-related admissions. Survival was better with a return to normal serum lactate within 12 h. On the other hand, the RPG levels may not be useful in prognosticating patients. However, a combination of serum lactate, RTS (at 24 and 48 h), and RPG at 48 h may improve predictive parameters in trauma related cases. This, however, requires further studies.

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Conflicts of interest
There are no conflicts of interest.

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