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Original Research Article.

Serum Lactate and Base Deficit as a Predictor of Morbidity and Mortality In Shock Patients of Trauma and Sepsis in Surgical ICU

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ABSTRACT

Objectives: To determine whether lactate levels and base deficits in critically ill surgical intensive care unit (SICU) patients correlate and whether either measure is a significant indicator of mortality and morbidity.

Methods: A review was made of 50 SICU patients who had serial lactate and blood gas measurements. Initial and 18th hour lactate and base deficit levels, as well as time to lactate clearence were compared among survivors and non survivors for the entire group.

Results: Initial and 24-hour lactate level was significantly elevated in nonsurvivors versus survivors (P = 0.002). Initial base deficit was not significantly different; 24-hour base deficit did achieve statistical significance (P = 0.02). The Middle age group from 21 to 40 yrs form the largest subset of population affected. The prdicted mortality rates by the serial lactate levels at admission, 6th hours, 12 hours, and 18th hour for both trauma and sepsis are 31.81%, 59.09%, 72.72% and 81.81%. There was poor correlation between initial and 24-hour lactate and base deficit among all patients (r = -0.3 and -0.5). Mortality if lactate normalized within 24 hours was 10%, compared with 24% for >48 hours and 67% if lactate failed to normalize. Physical status at discharge was related to initial lactate (P = 0.05), as well as to lactate clearance time (P = 0.01).

Conclusions: Elevated initial and 24-hour lactate levels are significantly correlated with mortality and appear to be superior to corresponding base deficit levels. Lactate clearance time may be used to predict mortality and is associated with outcome at discharge. Initial base deficit is a poor predictor of mortality and did not correlate with lactate levels except in trauma and sepsis nonsurvivors. In addition to being used as an endpoint for resuscitation, lactate may be predictive of certain morbidities and patient outcome at discharge.

Key words: Serum Lactate, Base Deficit, Surgical ICU.

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INTRODUCTION

The definition of shock has evolved with our understanding of the underlying pathophysiology process responsible for shock syndrome. In our current understanding, shock is defined as "an abnormality of the circulatory system that results in inadequate organ perfusion and tissue oxygenation". Whether caused by hemorrhage, cardiac dysfunction, and / or sepsis, the common denominator in all shock states is a critical decrease in oxygen and nutrient delivery to cells resulting in altered cellular metabolism, cell death, organ failure and ultimately death.

Trauma is the third overall cause of death and the first before 40 yr of age, and is responsible for handicaps and high costs.[1] Most deaths (80%) occurred within 48 h and hemorrhage continues to be one of the two leading causes of death.[2] The main principles of trauma patient care are to recognize and treat hemorrhage early, limit the consequences of shock, and diagnose traumatic lesions. Hypoperfusion is still difficult to diagnose and remains so and favors adverse inflammatory and immunologic effects, coagulopathy, development of infection and organ failures, and finally precipitates to late mortality.[3]

Measurement of serum lactate and base deficit concentrations are another tool used in critically ill adults, for assessing tissue perfusion. Studies in experimental animals and critically ill adults have shown that the degree of increase in blood lactate is proportional to the severity of oxygen deficiency and the decrease in oxygen delivery. Blood lactate concentrations in critically ill and injured adult patients can be used to detect tissue hypoxia at an early stage, assess illness severity, and predict outcome. Serial measurements of blood lactate concentrations are more valuable than a single measurement, not only in providing a more precise assessment of prognosis, but also in evaluating response to treatment.

The base deficit (BD) is defined as the amount of base, in mill moles, that is needed to normalize the pH of 1L of whole arterial blood to 7.4; with the sample fully oxygen saturated at 37^0 C with

a $PaCO_2$ of 40 mm Hg. Base deficit can also be used as an approximation of global tissue acidosis. An extreme or abnormal base deficit, for the purposes of this study, is defined as a base deficit which has been established as a reliable endpoint of resuscitation. Base deficit has also been shown to have a strong relationship to indices of tissue oxygen utilization and to reflective of tissue oxygen consumption even in compensated shock. Base deficit and lactate concentration have been established as end points of resuscitation in critically ill patients. However, obtaining these data has traditionally required an arterial blood gas sample. We hypothesized that the more easily available serum bicarbonate (SB) concentration could approximate base deficit and potentially serve as a useful end points of resuscitation of critically ill or shock patients. We evaluated retrospectively the correlation of serum bicarbonate with base deficit in a cohort of surgical Intensive Care Unit patients. 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] Lactate clearance has recently emerged as an important concept in septic shock, as part of the quantitative resuscitation concept that aims to reach predefined physiological goals to be achieved within the first hours.[8] Several studies have shown that poor lactate clearance is associated with increased mortality during septic shock[9-11] and after cardiac surgery.[12,13] The oxygen debt during tissue hypoperfusion leads to anaerobic metabolism, accumulation of serum lactate and metabolic acidosis. Davis JW suggested that base deficit can be used as an indicator of depressed oxygen delivery for those in a state of shock and would be useful in the clinical diagnosis of compensated shock.[14] The improvement in the base deficit can also access the efficacy of fluid resuscitation. It has been proposed that organ damage in critical illness is due to inadequate oxygen delivery that fails to satisfy metabolic needs.[15] The failure of serum lactate levels to reach normal values within a specific time during critical illness could be even more closely related to survival then the initial levels.

METHODS

The charts of 50 consecutive surgical admissions to the Rama Medical college Hospital and research centre Pilkhuwa Hapur U.P. intensive care unit (ICU) from august 2017 to august 2018 were reviewed retrospectively. All patients were admitted to the ICU by the casualty department for the identified purpose of resuscitation from shock due to trauma, burns or as a consequence of a major abdominal catastrophe. Vascular and cardiothoracic patients were excluded. Patients below 12 yrs of age, with serious medical conditions like hypertension, diabetes mellitus, Congestive heart disease, malignancy and liver disorders were also excluded. All patients had both serial lactate and base deficit measurements determined simultaneously within 1 hour of admission. Data obtained from the trauma registry included age, sex, BD, pH, trauma score, probability of survival, length of stay, length of intensive care unit stay (ICU days), complications, and survival. All patients had an initial arterial lactate with calculated base deficit measured at the time of admission to the ICU. Our routine protocol is to check lactate levels and base deficit every 6 hours during the initial resuscitation, but the timing of repeat measurements was at the discretion of the managing surgical team. A normal lactate level was defined as </= 2 mmol/L or 9-20 mmol/dl. Normal base deficit/excess was defined as that between 2 to -2 mmol/L. Demographic, hemodynamic, laboratory and outcome data were recorded.

Initial and 18th hour lactate and base deficit levels, as well as time to lactate clearance were compared among survivors and non survivors for the entire group. Patients were also stratified into four groups based on lactate clearance time. Group 1 never achieved normal lactate levels. Group 2 normalized lactate levels within 12 hours. Group 3 achieved a normal lactate levels between 13 and 18 hours, and group 4 took longer than 18 hours to normalize. The hospital blood bank transfusion data base was used to determine packed red blood cell (PRBC) transfusion in the first 24 hours, total hospital PRBC transfusion, and total fresh frozen plasma transfusion. These groups were than compared with respect to mortality, morbidity and functional status at time of discharge.

Parametric data were analyzed by Chi-square test. Statistical significances were set at a P value < 0.05. Statistical analyses were performed using Microsoft Excel.

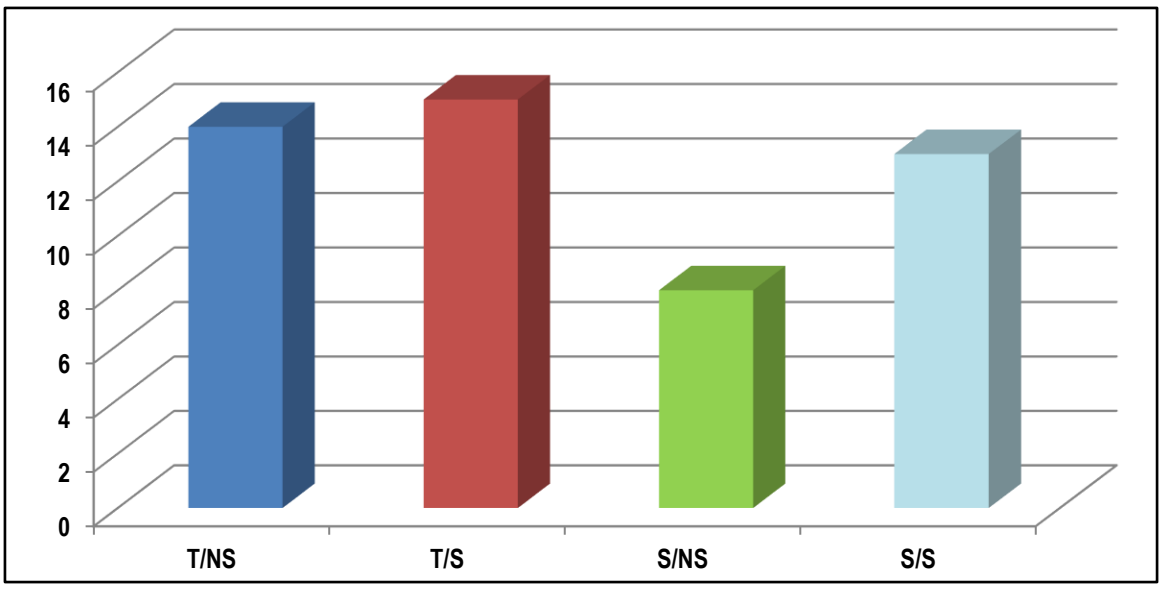

Fig 1: Distribution of Patients of Trauma and Sepsis

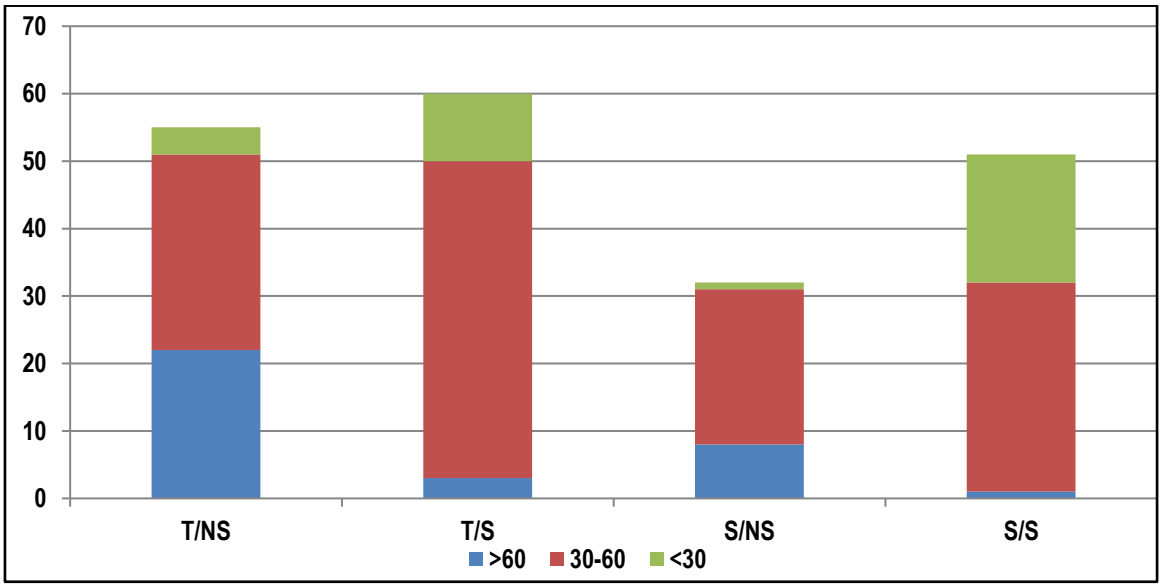

Fig 2 a: Lactate Values as a Quantum

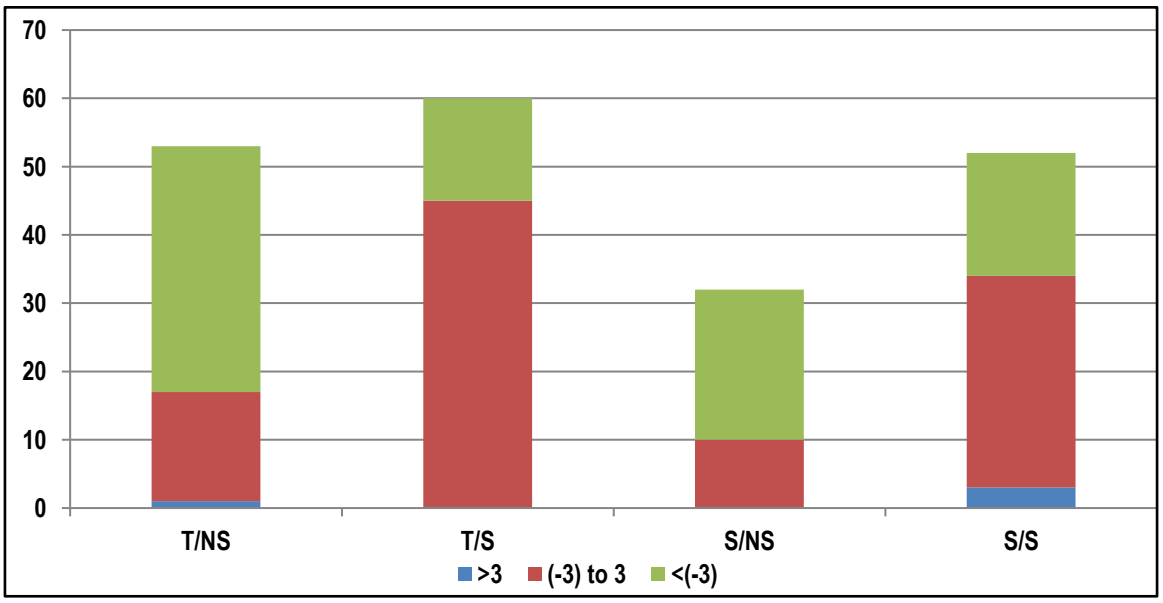

Fig 2 b: Serial Base Deficit Values as Quantum

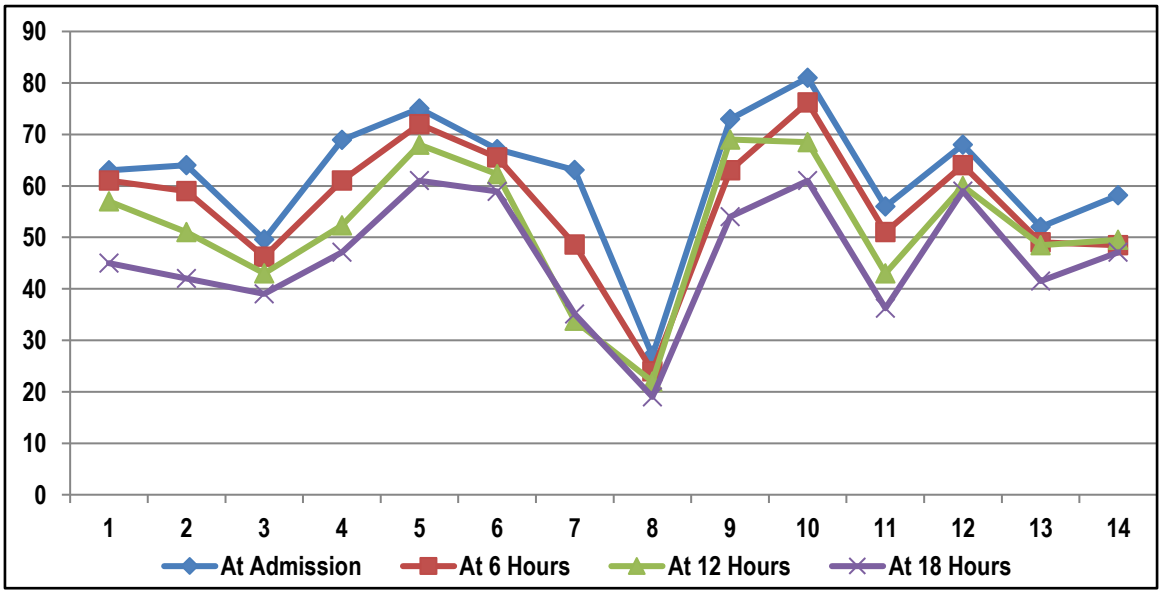

Table 3 a (i): Serial Lactate Values in Non Survivors of Trauma

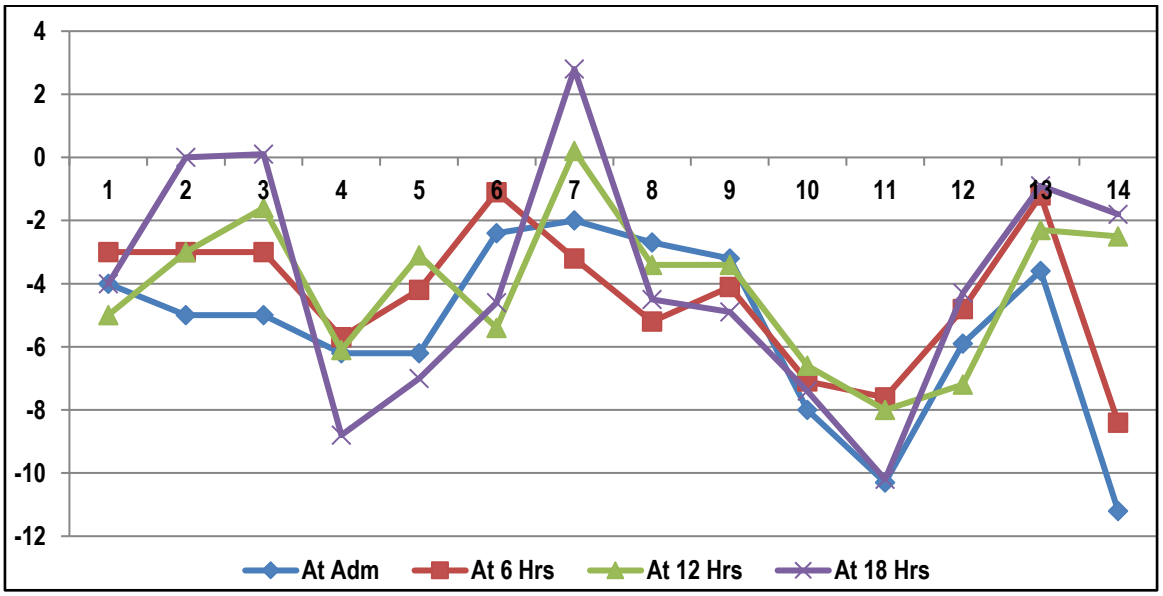

Fig 3 a (ii): Serial Base Deficit Values in Non survivors of Trauma

Table 1: Variables at admission and at 18th hrs in different categories

Variables	T/NS	T/S	S/NS	S/S
NO.	14	15	8	13
AGE (Yrs)	14-70	13-65	22-82	18-65
SEX				
M	9	13	5	9
F	5	2	3	4
AT ADMISSION				
Pulse	120-140	110-140	110-144	112-145
Blood Pressure	NR-100/70	80/40-90/70	90/60-90/70	80/50-90/70
Sodium	120-146	123-138	122-135	129-148
Potassium	3.5-5.6	3.2-5.9	3-5.5	3.1-5.8
Chloride	83-102	81-100	78-100	86-103
Bicarbonate	19-35.2	21-29.6	25.4-37	20.6-29.9
Serum Lactate	27-81	35-65.2	43-82.1	33.1-59.2
Base Deficit	(-11) - 5	(-5.6) – 1.9	(-13) – (1.4)	(-6) – 3.4
AT 18TH HOURS				
Pulse	116-132	98-116	96-140	108-120
Blood Pressure	90/00-100/70	100/60-130/80	80/00-110/70	100/60-140/90
Sodium	128/134	130/145	133-141	134-142
Potassium	4-5.2	3.8-4.6	3-4.9	3.4-4.6
Chloride	92-102	95-101	86-100	69-101
Bicarbonate	21.2-34.2	21.5-26.8	24.3-37	21.5-28.4
Serum Lactate	19-61	21-46	30-61	13.6-39.2
Base Deficit	(-10)-2.8	(-2.8) – 2.5	(-13) –(-0.3)	(-4.4) – 2.5
ORGAN DYSFUNCTION	14	9	7	7
SURGERY	7	12	5	10

RESULTS & DISCUSSION

Huckabee first noted a measurable increase in serum lactate in the presence of anaerobic metabolism and correlated access elected with oxygen dept. Other investigations have noted a similar increase in serum lactate levels with tissue hypoperfusion. Broder and wale in the investigations on the reversibility of shock demonstrated that increase in both lactate and excess was associated with increasing mortality.

One of the first authors to document the association between persistent and morbidity and mortality was Abramson, who in1993 found that mortality was higher in patients with delayed drop in lactate levels down to baseline after 24 to 48hours, and that

survival was higher among those who achieved 100% LC within the first 24 hours.[16] More recently, Cannizaro et al related serum lactate to mortality and demonstrated a significant reduction in lactate and excess lactate with resuscitation of shock.[17] Similar results were obtained by James et al in battle casualties. While the serum lactate levels is failed to be reliable physiologic indicator of hypovolemia, the laboratory determination is too time consuming for use in acute setting.

The base deficit is readily and rapidly obtainable and as a nearly stoichiometric relationship to serum lactate. This relationship was confirmed when James et al and Cannizaro et al noted a decrease in base deficit associated with normalization of serum lactate levels after resuscitation.[17]

Our report indicates that initial serum lactate and base deficit values at admission is a reliable indicator of the relative magnitude of volume deficit. The volume of fluid required for resuscitation was greater in the groups with the more severe base deficit.

The results of this study indicate that lactate level is superior to base deficit as a marker for shock and resuscitation. Lactate levels on admission and after 18 hours in hospital separate survivors from non survivors. This relationship held true for trauma patients, non trauma surgical ICU patients, and all patients combined, making it are useful market for potential mortality in all types of shock encountered.

Of the 50 patients enrolled in the study on the basis of inclusion criteria, 29 were patients of trauma admitted to ICU or in some cases, to general ward. These patients have varying degree of severity of injury and were managed by different units as deemed necessary. An observation of change of hemodynamic variables and corresponding serum lactate values (4 values 6 hour apart) was done. The same was done for patients suspected to have ongoing sepsis (21) patients including septic shock or organ dysfunction. Lactate and base deficit values were then used as a variable, being followed serially, to make an early detection of deterioration of improvement in the condition of patient.

Serum lactate and base deficit levels are known to be predictors of survival or mortality in patients of trauma and sepsis.[18] A normalization of serum lactate and base deficit values with aggressive treatment within 24 hours of insult has been shown by others to have a favorable outcome. Aggressive treatment includes timely resuscitation, antibiotics, Surgical Management, vasopressors and inotropic drugs. The aim of all intervention remains patient survival. However, the patient presents with a pre-existing set of variables of morbidity that affect his response to an insult and hence the results of these interventions differ between patients.

More significant than absolute lactate level as a marker of shock and resuscitation was the time to lactate clearance- the time it took for blood lactate level to return to a normal level.[19-21] Survival was 90% if lactate could be normalized within 24 hours, compared with 33% if lactate could not be normalized. It should also be mentioned that this is a conservative analysis of the power of lactate clearance time as several patients were included in group 4 who clearly responded well to resuscitation but did not have lactate values observe to normalization (in violation of protocol)l. If these patients were excluded, survival in the “never cleared” group, the mortality would approach 100%. This is consistent with the other studies reporting that time to clearance of hyperlactatemia is important to Survival.

In a group of trauma and sepsis, certain known primordial variables (eg. Diabetes, hypertension, pulmonary tuberculosis, AIDS, malignancy, typhoid etc) have been excluded. A serial evaluation of lactate and base deficit values in blood was done to assess responses to all interventions being done with the presumption that value would predict the outcome of an insult to the patient. However, it would be wise to state at the onset that the process of recovery from such an insult (trauma or sepsis) is a very long one. Hence, while the study included for lactate and base deficit values over and 18 hour period, the fun final outcome may have been affected by a fresh insult following a few too many days after the observed episode. However, this would have been known only if daily regular levels of both were followed from the day of inclusion into study till the final outcome. This was not done due to financial and other constraints.

It was observed in certain patients that even though lactate values over the study period decreased, the final outcome was mortality.[22] And in all these patients there is prolonged Hospital stay. Hospital stay as a variable is not taken into study but surely it predicts the patient survival and any intervention about the disease process overpowered a favorable outcome. This therefore adds the time and effort needed for these patients to make survival possible.

An analysis of lactate values as an Quantum in the survivors and non survivors of trauma and sepsis shows the higher set of values in non survivors i.e. 22 out of 55 lactate values (40%) were >60 mg/dl and 29 out of 55 (52%) were in 40-60 mg/dl range in trauma group. While that of Base deficit range in nonsurvivors of trauma there are 36 out of 53 values, which were in severe subgroup i.e. < -3 mmol/L range (68%) and 16 out of 53 values were between -3 to 3 mmol/L(30.18%). The p-value significant that is < 0.05.

In non survivors of sepsis, the lactate values 8 out of 31 (25%) were in > 60 mg/dl and 21 out of 31 (74.19%) were in 30-60 mg/dl range. While that of base deficit values 20 out of 32 (68.75%) were in <3 mmol/L and 10 out of 32 values were between -3 to 3 momol/l (31.25%). The patients of trauma have higher values than patient of sepsis. This shows that a set of both values are more valuable marker than a single value. The P value is significant i.e. < 0.05.

The study could also have included a mention of inotropic and vasopressors drugs used, analysis of crystalloid versus colloid, etc. The uses of inotrops in the patients of shock are documented to increase tissue perfusion and decrease serum lactate values.

In contrast the use of serum adrenaline has been shown to increase lactate values.

An analysis of the age distribution of non survivors and survivors of trauma and sepsis shows that the maximum number of patients were of age group of 21 to 40 years in all four categories. About one third of patients of trauma and sepsis nonsurvivors (36.4 % and 33.3%) and sepsis survived (37.5%) work of this age group. Two third cases of trauma survivors are of same age group. The stress is on the importance of measures to overcome the mortality in the growing epidemic of trauma and sepsis in the young age people.

A look at the table of baseline and 18 hours characteristically shows greater age variance in non survivors of trauma and sepsis. Male group are on higher sides, there is a higher level of pulse at admission as compared to 18th hours, low levels of sodium chloride at admission as compared to 18th hour, range of lactate

values are lower in survivors then in non survivors at admission and 18th hours in general the patient in sepsis have greater tachycardia, low BP, relative low sodium and chloride, less bicarbonate, higher lactate values then trauma patients on admission.

Overall the incidence of manifestation of organ dysfunction is more in non survivors then survivors. In patients of trauma, 14/14 non survivors and 9/15 survivors developed organ dysfunction. In the sepsis subgroup, 7/18 non survivors and 7/13 survivors develop organ dysfunction. Morbidity may include renal failure, brain damage, gut ischemia, hepatic failure, metabolic derangements, diffuse intravascular coagulation, acute respiratory distress syndrome, cardiac failure and death. No mention is made on the surgical intervention due to the difference in the nature and severity of injury in trauma patients. For the no correlation could be established between lactate and base deficit levels and the type and number of organ system involved in organ dysfunction.

Some survivors of trauma had very high lactate values on admission. Their subsequent lactate levels were decreased. Hogan et al in a study have noted that some patients with only minor injuries have a very high lactate levels at admission. Mechanism and location of injury did not significantly dictate morbidity and mortality in this group. They concluded that those patient with associated hypertension or large blood loss need in patients admissions. Otherwise discharge within 24 hours may be acceptable when clinically cleared. A very high admission lactate alone does not mandate in patient admission.[23]

Patients with extensive burns especially those appeared late on admission in a very critical condition or burns involving extremities who had no assessable sites for measuring blood pressure were resuscitated on empirical formula of burn resuscitation. The use of lactate and base deficit values as a marker of resuscitation will therefore prove to be a worth in this group of patients.

SUMMARY AND CONCLUSIONS

Trauma and sepsis are the largest illnesses that plague population all over, especially the young and Middle Age. Efforts are ongoing the world over to understand the mechanism, involved in the complex chain of events set off in these critical patients, to offer elective resuscitation and supportive treatment, to improve chances of survival, to offer a life that is productive and meaningful. Understanding about various parameters of Human Physiology that could be monitored to gain an insight into ongoing events into body has increased over the years gone by. Technology has given a boost to all aspects of medicine.

Optimizing of hemodynamic parameters, as judged by non-invasive and also invasive monitoring available may leave a considerable number of patients in “compensated shock”.

Global hypoxia when allowed to persist leads to organ dysfunction and death. Lactate and base deficit level in blood has been known to be a marker of hypoxia. The study was undertaken to see the utility of serial blood lactate levels and base deficit values as a predictor of morbidity and mortality in patients of shock in our setup, in critically ill patients.

The study included 50 patients in the age group of 13 to 65 of from admitted within 12 hours of injury and patients of suspected or proven sepsis. Patient suffering from chronic medical illness of diabetes, hypertension, typhoid, pulmonary tuberculosis, chronic renal failure, epilepsy and HIV, etc. was excluded from studies. Also patients admitted with history of alcohol intoxication and poisoning were excluded. Patients also of head injury or psychiatric disturbances were excluded. Serial serum lactate and base deficit values were analyzed at admission, 6 hours, 12 hours, 18 hours of inclusion and records corresponding hemodynamic variables were kept. Data also noted regarding investigation records and intervention including surgery. Outcome was recorded into survivor and non-survival.

An analysis of observation revealed higher mean lactate levels in non-survivor as compared to survivors. Also mean values in serum lactate levels in non survivors did not attain normal levels by 18 hours in trauma patients and normal levels in sepsis patients. The predicted mortality rates by the serial lactate levels at admission, 6 hours, 12 hours and 18 hours for both trauma and sepsis are 31.81%, 59.09%, 72.72% and 81.81%.

The predictive mortality rates by serial base deficit values are 66.21%, 66.21%, 68.18% and 68.18%. Maximum patients were at the age group of 21 to 40 years i.e. the middle age group.

A look at the table of patients of admission and at 18 hours characteristic showed higher range of pulse in non survivors of trauma and sepsis, lower range of BP, lower range of sodium and chloride and higher range of potassium and Bicarbonate and so the base deficit. In general the patient with sepsis had greater tachycardia, lower BP, low lactate levels and base deficit values. Non survivors had higher incidents of organ dysfunction. No correlation could be found between lactate and base deficit values and the type and number of organ dysfunction.

The following conclusion can be drawn from the presents study: 1)Serial lactate and base deficit values followed over a period of time can be used to predict impending complications or grave outcomes in patients of trauma and sepsis. This middle age group from 21 to 40 years form the largest subset of population affected underlying the importance of such marker.2)Trauma resuscitation that decrease lactate and base deficit values to near normal by 18th hour can be considered effective therapy. 3)Both lactate and base deficit values that increase serially or persist at high levels indicate ongoing worsening of patient’s condition, which may be unrecognized otherwise and the need for more aggressive treatment. They also hint at the need for greater resources of the hospital and the patient.4) Patients of sepsis have low lactate and base deficit values in comparison to trauma patients. Intervention that decreases these values to normal by as early as 18th hour may improve chances of survival.5) Lactate and base deficit values need to be followed for longer periods in critically ill patients even when they have tided over the present crisis. The utility of regular lactate and base deficit analysis would depends on factors such as availability and cost of test also. There are no existing studies to support the above premise.6)Traditional parameters of monitoring no doubt have value in following patient condition: however serial lactate values afford more objective appraisal.7) Also in patients with burn injury who have extremity burn and are non-invasively monitored, resuscitation can be guide by monitoring lactate and base deficit values.

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