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Serum Lactate – An indicator of morbidity & mortality in Polytrauma patients

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***Abstract*:** *Trauma is a major worldwide cause of death and disability that mainly affects young adults and the elderly population. The definition of multiple traumas varies among surgeons from different specialties and between different centers and countries. Hence the need for comparative analysis of injury, management & outcome related parameters has stimulated the development of many trauma scoring systems. These scoring systems represent a means of quantifying the injuries along with comorbidities, age and mode of injury. They are based on converting many independent factors into one-dimensional numeric value that ideally represents the criticality of the illness. An ideal scoring system should take into account the severity of anatomic trauma, level of physiologic response & inherent patient reserves. Aim of the study is to study the significance of blood parameters at the time of admission in predicting the morbidity & mortality of multiply injured patients mainly to understand the significance of blood lactate and lactate clearance in polytrauma and compound injury patients and its roll in predicting timing of definitive and reconstructive procedures in polytrauma and compound fractures.*

***Keywords*:** *Polytrauma, Injury Severity Score, Serum lactate, Lactate clearance, Damage Control Surgery.*

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I. Introduction

Trauma is a major worldwide cause of death and disability that mainly affects young adults and the elderly population[(1)]. The definition of multiple trauma varies among surgeons from different specialties and between different centers and countries. Polytrauma patients are the subgroup of injured patients who have sustained injuries to more than one body region and organ with at least one of the injuries being life-threatening. For uniformity, polytrauma is defined as injuries with injury severity score more than 16.Trentz emphasized the pathophysiologic systemic impact of multiple trauma when he defined polytrauma as "a syndrome of multiple injuries exceeding a defined severity (ISS ≥17) with sequential systemic reactions (systemic inflammatory response syndrome [SIRS] for at least 1 day) that may lead to dysfunction or failure of remote organs and vital systems, which have not themselves been directly injured."[(2)]

An organized trauma care is necessary to reduce the mortality due to polytrauma, which consists of a good pre-hospital and in-hospital care and rehabilitation. Research and constant reevaluation are necessary for continuous assessment of the system and improvement of its outcome and efficiency.

At present, the severity of the injury and need for intensive monitoring and care are decided based on the basic vital parameters and trauma scoring systems. Systolic BP less than 90 mmHg is considered as shock and resuscitated intensely. According to a recent study, shock index is considered superior to systolic BP in diagnosing haemorrhagic shock. Shock index is defined as the ratio between heart rate and systolic BP. Shock index of > 0.9 is considered significant and intensive monitoring and care is given to combat occult hypoperfusion.[(4)]

In an uninjured, healthy, nonseptic state, oxygen consumption is a regulated process because oxygen is used in the generation of energy from a variety of metabolic fuels[(4)]. In case of occult haemorrhagic or septic shock, the oxygen delivery to the tissue is drastically reduced creating a crisis of ischemic metabolic insufficiency. When oxygen saturation reduces below the threshold limit, the tissues go in for a state of oxygen debt or oxygen deficit which is defined as the integral difference between the pre-trauma/pre-haemorrhage oxygen saturation and saturation during the hypovolemic, haemorrhagic phase.

The presence of oxygen debt is further emphasized by the accompanying metabolic acidemia due to increased anaerobic activity. Metabolic acids in blood are indices that reflect the degree of tissue hypoxia associated with hypovolemic ischemia. In this review, the strict definition of base deficit (BD) – namely, a negative base excess – is used with a decrease in base excess with increasing metabolic decompensation implying progressively negative values (e.g. –6 mmol/l to –10 mmol/l). However, because BD implies a negative base excess, only positive values of BD (without the minus sign) are used.

The base deficit is proved to be one of the best predictors of occult hypoperfusion. The admission BD was one of the five best predictors for outcome (BD, GCS, age, prothrombin time, and ISS) [(5)]. Each of these five variables contributes significantly to the prediction of severity and mortality.

Of all the above said vital and blood parameters, we hypothesize that elevated serum lactate gives clear indication that the amount of oxygen in the blood is insufficient and causes debt in the tissues, thus having risk of multi organ dysfunction syndrome. In many of the studies, lactate was shown to predict outcome following postoperative complications, intracranial pressure, infection, sepsis, adult respiratory distress syndrome (ARDS), MOF, injury and haemorrhage severity and survival[(6).]

SERUM LACTATE AND ITS SIGNIFICANCE IN POLYTRAUMA

Lactate production occurs in all tissues like brain, skeletal muscles, RBCs & kidneys even at baseline conditions under oxygen rich level. In normal conditions, lactate is rapidly cleared by liver metabolism & by reconversion of lactate to pyruvate. This helps in keeping blood lactate level less than 9 mg/dl. In an occult hypoperfusion state, anaerobic metabolism prevails wherein pyruvate is metabolized to lactate, finally producing less number of adenosine triphosphate (ATP) molecules (2 vs 36) than through the normal aerobic mechanism via TCA cycle. Persistent lactic acidosis may lead on to respiratory failure, multi organ dysfunction or death following major trauma[(7)]. Lactic acidosis thus indicates occult or overt hypoperfusion.

Resuscitation in polytrauma patients has been traditionally guided by normalization of vital signs such as blood pressure, urine output & heart rate. However, these parameters have been proved to be inadequate in detecting the endpoint of resuscitation in critically ill patients. The ideal marker should be able to assess resolution of hypoperfusion. There have been few studies to date evaluating the significance of elevated blood lactate in detecting occult hypoperfusion. Persistent occult hypoperfusion has been proved to be associated with increased morbidity & mortality and early correction seems to improve clinical outcome[(8)]. There have been only very few studies assessing the prognostic value of blood lactate values on the outcome of high-risk, haemodynamically stable, trauma patients.

The field triage decision to transfer the trauma patient to a deputed trauma center should be systematic, rapid & accurate. At present, only heart rate, systolic blood pressure & urine output are used to decide transfer decisions, all of which are unreliable measures of acute haemorrhage. Systolic BP less than 90 mm Hg is still commonly used clinically to classify patients with shock, although ATLS suggests that relying solely on systolic BP to identify shock will result in delay in recognition of significant haemorrhage.

Although we historically consider systolic BP of less than 90 mm Hg as shock, there is limited evidence to suggest that tissue hypoperfusion& ischemia are limited to patients with SBP< 90mmHg. Recent studies suggest that SBP of less than 110 mm Hg may more accurately reflect the first physiologic response of shock. Therefore, close monitoring of patients with SBP of 90-110 mmHg is needed to identify occult shock. But, expanding the trauma triage may lead on to over-triaging and extract the already resource-strapped trauma centers. Here comes the usefulness of serum lactate and base deficit in recognizing patients with occult hypoperfusion or early shock secondary to haemorrhage[(9)].

Shock is responsible for inadequate oxygen delivery, resulting in tissue hypoxia, anaerobic metabolism, and lactate production. Lactate is thus a diagnostic and prognostic biomarker in sepsis and trauma. Lactic acidosis may persist despite controlling haemorrhage, due to flow demand mismatch, vasoconstriction, shock or other dysfunctional responses.

SIGNIFICANCE OF LACTATE CLEARANCE

Lactate clearance has recently been emerged as an important concept in haemorrhagic shock, as part of the quantitative resuscitation concept that aims to reach predefined physiologic goals to be achieved within the first hours. Studies show that poor lactate clearance is associated with increased mortality in septic shock[(10)]. Jones et al have shown that attempting to normalize lactate clearance is not inferior to normalizing central venous oxygen saturation in septic shock. In septic patients, lactate clearance is measured over a prolonged time period (from 6 to 24 hrs), which may not be appropriate in trauma.

In trauma patients, there is a need for rapid assessment of resuscitation and of the diagnosis of occult hypoperfusion during its early phase. There is a need for early prognostic indicator that may identify patients at high risk of death. Lactate clearance can be a good prognostic indicator in assessing the outcome in a polytrauma patient. Abramson et al observed that lactate level were normalized in patients who recovered well, but not in cases with poor outcome.[(11)]

Primary aim of the study is to study the significance of blood parameters at the time of admission in predicting the morbidity & mortality of multiply injured patients and to understand the significance of blood lactate and lactate clearance in predicting the morbidity & mortality of polytrauma and compound injury patients.

II. Methods

This was a prospective observational and analytical study from the period of March 2016 to September 2016. We selected 69 patients of multiply injured and compound injury patients admitted in our emergency trauma ward. Patients for my study were selected using the inclusion and exclusion criteria formed.

Inclusion criteria

- ❖ All compound fractures of lower limbs
- ❖ Polytrauma patients with ISS more than 16
- ❖ Both male & female of age above 14
- ❖ Trauma patients with hypovolemic shock on arrival

Exclusion criteria

- ❖ Closed isolated long bone and/or small bone fractures
- ❖ Isolated ankle & foot compound injuries
- ❖ Associated spinal cord injury with neurological deficit
- ❖ Patients with H/o taking immunosuppressive/ ART drugs

Patient was first received in the emergency ward and vital parameters, namely heart rate, systolic BP, mean arterial pressure, urine output, SPO2, GCS, respiratory rate and temperature were measured and recorded along with other information including demographic data. The prehospital time was noted, which is the time interval between time of injury and arrival to the hospital. Details of pre-hospital care given were recorded. Then resuscitation was started according to standard ATLS protocol. Abbreviated Injury Score of all external injuries and total New Injury Severity Score were calculated.

Mangled Extremity Severity Score and Ganga Hospital Open Injury Score were calculated for all compound fractures. Blood collected and sent for routine investigations, blood grouping and cross matching and also for serum lactate measurement. Blood transfusion was planned according to the clinical observation and Hb and PCV values. Once the patient got stabilized, he was shifted for investigations like X rays, CT scan, USG, ECG, etc... Any immediate lifesaving procedures like intercostal drainage, thoracocentesis, needle thoracotomy, pelvic external fixator, fracture splintage were done in the emergency ward itself. The decision regarding implementation of damage control orthopaedics vs early total care was made according to the existing guidelines. All compound grade 2 & 3 fractures were taken for emergency wound debridement and external fixator application. The comorbidities were simultaneously found out, necessary specialists' opinions obtained and interventions given as needed.

All vital parameters were continuously monitored. Serum lactate was again measured at 6 hours and then at 24 hours. Blood sugar, urea, creatinine, complete blood count, serum electrolytes were measured again after 24 hrs. Intensive monitoring and care were given till all vital parameters became normal. Oxygen support was given when pulse-oximeter showed reduced oxygen saturation in blood and stopped when it rose to more than 95%. Endotracheal intubation and ventilator support were given with the help of duty anaesthetists in case of acute respiratory distress or respiratory arrest. Inotropes were sometimes given with the advice of intensivists. Any complications were identified early and managed quickly.

Once the patients' vitals had become normal and considered free from all complications, they were transferred to the wards and definitive treatment planned.

ENDPOINTS

The final outcome of the patient was measured qualitatively as follows.

1) Early death of the patient, defined as death within 48 hrs,
2) ICU length of stay more than 2 days
3) Death within 30 days/ complications like sepsis, MODS,etc.
4) Recovery with sequelae/ Late recovery
5) Full early recovery

Apart from this, the requirement for an emergency procedure like intercostal drainage, emergency surgery, emergency embolization, or emergency transfusions were recorded.

METHOD OF SERUM LACTATE MEASUREMENT

Serum lactate measurement is used to assess acid-base status of the blood and is done to diagnose lactic acidosis and thus hypoperfusion and shock. Enzymatic methods are now preferred to calorimetric and titrimetric methods as it is simple, accurate, specific and reproducible. The first enzymatic method was based on transferring hydrogen ion from lactate to potassium ferricyanide by lactate dehydrogenase which is cumbersome. Subsequent methods involved the UV measurement of the formation of NADH. [12,13]

In 1974, Gutman and Wahlefeld described a method that measures NADH formed from lactate by LD, using hydrazine as a trapping agent for pyruvate. A method described by Noll is also based on the catalytic action of LD but uses ALT to more rapidly remove the pyruvate.The method done in this study uses an enzymatic reaction to convert lactate to pyruvate. The hydrogen peroxide produced by this enzymatic reaction is then used in another reaction to generate a colored dye. This method offers longer reagent stability than the previously described methods. [14]

Test principle

Calorimetric assay

L-Lactate is oxidized to pyruvate by the enzyme lactate oxidase (LOD). The hydrogen peroxide formed as a byproduct is then generated into a colored dye by peroxidase enzyme (POD).

$$\text{L-Lactate} + O_2 \xrightarrow{\text{(LOD)}} \text{Pyruvate} + H_2O_2$$
$$2\,H_2O_2 + \text{H Donor} + 4\,\text{AAP} \xrightarrow{\text{(POD)}} \text{Chromogen} + 2H_2O$$

The intensity of the color is directly proportional to the L-Lactate concentration. It is determined by measuring the increase in absorbance.

Blood specimens are collected in sodium fluoride (Na F) coated blood collection tubes and stored in ice box. The sample is then transported to the biochemistry laboratory and centrifuged within 15 mins. Serum lactate concentration is then measured with above said method using auto analyzer. The level is measured in mg/dl and can be converted to mmol/l using the conversion factors.

mmol/l × 9.009 = mg/dl
mmol/l × 90.09 = mg/l
mg/dl × 0.111 = mmol/l

The coefficients of variation of the measurement of blood lactate were 3.8% (at 1.15mm/l) and 2.6% (at 4.5 mm/l) in our laboratory. We analyzed previous studies and observed that the threshold for abnormal values was 19.8 mg/dl (mean and median extremes being 18 and 21.5 mg/dl). Thus, the normal range is considered as 19.8 mg/dl or lower.

Lactate clearance is then calculated using the formula-

$$\text{Lactate clearance} = \frac{(\text{Lactate initial} - \text{Lactate delayed})}{\text{Lactate initial}} \times 100$$

The lactate clearance is calculated at 0 – 6 hrs, 0 – 24 hrs and then at 6 – 24 hrs.

III. Statistical Analysis

Serum lactate and lactate clearances of all patients are measured and charted along with all parameters. Outcome variables are also recorded in defined manner. Mean and standard deviations were calculated for each variable. Comparison of two means was performed using unpaired student t test, comparison of two medians was performed using Mann – Whitney test, comparison of proportions was performed using fisher exact method. Correlation between two variables was assessed using linear regression analysis. [15]

Multiple logistic regressions were performed to assess the role of serum lactate and lactate clearance. We included initial lactate level, lactate clearances and ISS scores. Discrimination of the final models was assessed by measurement of area under receiver operating characteristic curve and their calibration by Hosmer-Lemeshow statistic. Odds ratios and their 95 % confidence interval were calculated.

IV. Results

We analyzed a total of 69 patients of mean age 40.61 years. As ours is a tertiary center and most of the patients are being referred from a nearby taluk or district headquarters hospital and also from various medical colleges, we received the patients after an average delay of 5.74 hours from the injury time. The patients those we analyzed were of average Injury Severity Score 20.72. The compound injury patients were of average mangled extremity severity score 4.18. The average SBP of the polytrauma patients we received was 99.42 and heart rate was 100.95, thus the average shock index being nearly 1. The average serum lactate at the time of admission was 35.08 mg/dl and lactate clearance in the first 24 hours was 15.181. Serum lactate was elevated in 67 patients.

According to our study, around 92% of patients analyzed under our inclusion criteria had sustained a road traffic accident. 5% sustained train traffic accident and 3% had fall from height. We observed 37% of RTA patients to have recovered early, whereas 40% recovered early in a TTA and all three patients who fell from height recovered early. There was no statistically significant correlation between mechanism of injury and final outcome (p value 0.519).

Around 5% of the patients did not need any ICU stay. 15% of the patients stayed in ICU for less than 12 hours. 30 % of the patients stayed for 13-24 hours, 32% for 25-48 hours and 18 % for more than 48 hours. All three patients who did not need ICU stay recovered very well. Of the 13 patients, who stayed for less than 12 hours in ICU, 2 patients died within that period. Hence, we found no statistically significant correlation between ICU stay and outcome (p value 0.029).

The decreased SBP at the time of admission results in poor outcome (p value 0.003). it was observed that the patients who recovered early, had a mean systolic BP of 103.8 at the time of admission. Patients who recovered late had a mean BP of 98.48, who recovered with sequelae had 94.46 and who died had a mean BP of 90.67. Thus we found a statistically significant correlation between systolic BP at the time of admission and the final outcome (p value 0.003).

Table 1 Se

	Outcome	**No. of patients**	**Mean Serum Lactate**	**Minimum Serum Lactate**	**Maximum Serum Lactate**
Sr Lactate mg/dl – on admission	Early recovery	29	25.61	17	35
	Late recovery	22	34.95	25	45
	Recovered with sequelae	14	44.22	24	70
	Death	4	75.27	68	85
	Total	69	35.08	17	85
Sr Lactate mg/dl - after 24 hrs of admission	Early recovery	29	19.13	15	22
	Late recovery	22	24.88	19	33
	Recovered with sequelae	14	33.00	20	65
	Death	4	61.20	58	64
	Total	69	25.44	15	65

rum lactate vs final outcome

In our study, we observed that the patients who recovered early had a mean serum lactate value of 25.61mg/dl at the time of admission and got their lactate value corrected at 24 hours after admission. Patients who recovered late had mean lactate value of 34.95mg/dl at admission and 24.88 mg/dl at 24 hours. Patients who recovered with sequelae had 44.22mg/dl at admission and 33mg/dl at 24 hours. Those who died had 75.27mg/dl at admission and 61.2mg/dl at 24 hours.

We can see clearly that increased lactate at the time of admission and persistent elevation of lactate at 24 hours resulted in very poor outcome (p value 0.0001 – highly significant). In one patient with compound Grade IIIB both bones leg fracture, whose injury severity score was just 16 at the time of admission and systolic BP of 98 mmHg at the time of admission predicted very good outcome as we relied only on these parameters. But the serum lactate of this patient was very much elevated which would have predicted the ongoing septicemia and crush syndrome if relied on lactate values for resuscitation and thus would have avoided the death of the patient.

Table 2 Lactate clearance vs final outcome

Outcome	**No. of Patients**	**Mean Lactate Clearance%**	**Minimum Lactate Clearance%**	**Maximum Lactate Clearance%**
Early recovery	29	13.023	-1.2	27.1
Late recovery	22	15.602	6.5	26.2
Recovered with sequelae	14	13.085	5.3	37.8
Death	4	2.910	-3.8	6.8
Total	69	13.017	-3.8	37.8

The significance of lactate clearance in predicting the final outcome was analyzed by ANOVA and post hoc hypothesis was subsequently formulated, which illustrated a significant association with p value of 0.025 (significant).The mean lactate clearance (0-24 hours) was calculated and observed that the patients who recovered early had a mean lactate clearance of 13.023%, whereas the patients who recovered late had 15.6, who recovered with sequelae had 13.09 and who died had mean lactate clearance of only 2.9%. We found a statistically significant association between poor lactate clearance and bad outcome in polytrauma patients.

Table 3ISS vs Serum lactate

		ISS	**Sr Lactate mg/dl**
ISS	Pearson Correlation	1	0.807
	Sig. (2-tailed)	0	0.001
	N	69	69
Sr Lactate mg/dl	Pearson Correlation	0.807	1
	Sig. (2-tailed)	0.001	0
	N	69	69

The correlation of Injury severity score and serum lactate at admission is checked which shows a significant correlation at 0.001 level (2-tailed).
Our study shows a significant positive correlation between injury severity score and serum lactate level at the time of admission.

Table 4SBP vs Serum Lactate

		Sr Lactate mg/dl	**SBP mm Hg**
Sr Lactate mg/dl	Pearson Correlation	1	-0.569
	Sig. (2-tailed)	0	0.001
	N	69	69
SBP mm Hg	Pearson Correlation	-0.569	1
	Sig. (2-tailed)	0.001	0
	N	69	69

The correlation of systolic BP and serum Lactate at the time of admission was checked which also showed a significant correlation at 0.001 level (2-tailed).The correlation study was also done individually between serum lactate at admission and amount of blood transfusions needed, length of ICU stay needed for the patient, any complications that the patient have faced and also the need of emergency procedures within 24 hours of admission which also gave mildly significant correlation, probably because of the relatively smaller sample size.

Table 5 Serum lactate vs Length of ICU stay

		Sr Lactate mg/dl –on admission	**Length of ICU stay in hours**
Sr Lactate mg/dl – on admission	Pearson Correlation	1	0.752
	Sig. (2-tailed)	0	0.001
	N	69	66
Length of ICU stay in hours	Pearson Correlation	0.752	1
	Sig. (2-tailed)	0.001	0
	N	66	66

Table 6 Serum Lactate vs Need for blood transfusion

		Sr Lactate mg/dl - on admission	**Blood transfused in units**
Sr Lactate mg/dl – on admission	Pearson Correlation	1	0.687
	Sig. (2-tailed)	0	0.001
	N	69	68
Blood transfused in units	Pearson Correlation	0.687	1
	Sig. (2-tailed)	0.001	0
	N	68	68

V. Discussion

In our study, we have found the following significant findings: Most of the polytrauma patients we analyzed are of very young age group. Around 36% of the patients belong to age group less than 30 years, 23 % belong to 21-30 years, 13 % belong to 41-50 years, 18 % belong to 51 – 60 years and 12 % more than 60 years. Literature also supports this fact and the reason might be due to increased road traffic accidents affecting young active individuals. Also we observed relatively good outcome in young patients, which could be due to better endurance and less co-morbidities.

Of the total 69 patients we took for study, only 4 were female and all others were male. Of the total 4 mortalities, 1 was a female and others were male. 62 out of 69 patients had sustained injury due to a road traffic

accident, 4 patients had train traffic accident and 3 patients had a history of fall from height. 3 patients of RTA and 1 patient of TTA died.

Of the total 69 patients, 13 patients required less than 12 hours of ICU stay and they all have recovered early except two patients who died before this period in ICU itself. There was a significant correlation between Injury Severity Score and final outcome shown in our study with p value of 0.001. But one patient with ISS of 16, who got compound Grade IIIB BB fractures of leg, fared well with external fixator on day 1 and suddenly succumbed to septicemia and ARDS on day 3. Hence, it shows that trauma scoring per se cannot predict outcome in all cases. The systolic BP at the time of admission correlates well with final outcome signified by a p value of 0.003. Literature says that shock index, which is a ratio of heart rate to systolic BP is a better predictor of outcome than systolic BP alone.

And lastly, we found that serum lactate values and lactate clearance in the first 24 hours correlates well with the final outcome. Patients who recovered early had a mean admission lactate value of 25.61 mg/dl and lactate clearance of 13.03%, whereas patients who died had a mean admission lactate value of 75.27 mg/dl and lactate clearance of 2.91%. The literature has reports both for and against serum lactate in predicting outcome in polytrauma patients. Several studies indicate that serum lactate at the time of admission and at serial intervals give a good prognostic value in major injuries, especially occult chest injury[16].

Blood lactate levels start rising as early as thirty minutes after major injury. Normal lactate levels depend on the age of the individual and whether arterial or venous samples are used. Lavery et al found no difference between venous and arterial lactate levels. Significant lactic acidosis is said to have occurred when serum lactate value goes above 45 mg/dl or blood pH drops down to 7.35. Serial measurements of lactate were found to have a better prognostic value than a single measurement.

Manikis et al studied 129 patients admitted to ICU and found that there was a significant difference in the mean lactate levels in survivors as compared to non-survivors[17] . Abramson et al studied lactate clearance in 76 multi-trauma patients admitted to the ICU and concluded that the time needed to normalize lactate levels is a useful indicator in predicting prognosis in severely injured patients.[18] Following major trauma, there is a surge of pro-inflammatory mediators, notably interleukin-6, until about the fourth day. The 'second hit' of any surgical intervention following the 'first hit' of the trauma itself is thought to have a deleterious effect on the outcome if any intervention is undertaken within this window. In a retrospective analysis of 4314 polytrauma patients, Pape et al. found that patients operated after 4th day fared better than those operated between 2 to 4 days with respect to development of multi-organ failure.[19]

In the setting of an acute lung injury, lactate levels increase as a result of endothelial damage, inhibition of pyruvate dehydrogenases and/or associated hypoxia and the resultant respiratory distress. Thus, elevated lactate values can be an important predictor of increased morbidity and mortality in trauma patients with an associated chest injury. In a study of 64 patients with torso trauma, Aslar et al. found lactate levels and the acute physiology and chronic health evaluation II (APACHE II) scores on admission to be predictive of survival.[20]

Persistent lactic acidosis is associated with higher rates of multiple organ dysfunction syndrome and respiratory failure and death after major trauma[12,21]. In our study, mortality rate for polytrauma patients with an elevated lactate was high. In our series, patients who had significant rise of serum lactate (>45 mg/dl) at admission and remained elevated throughout had worse prognosis than whose lactate was significantly high at admission and normalized rapidly within 24-48 hours. Severity of injury and serum lactate levels were also more on patients with occult lung injury.

The main findings in our study are the following;

1) Initial blood lactate values and lactate clearances provide valuable information about the severity of the injury and predict outcome and mortality.
2) Initial lactate values & lactate clearances correlate well with vital parameters at the time of admission and with trauma scorings
3) Our study indicates that lactate clearance gives good prognostic value in polytrauma patients.
4) Lactate seems to be a good prognostic indicator in trauma even in patients with normal vital signs.
5) Lactate levels at admission correlate well with the quality of pre-hospital care and injury-admission interval.

In various types of shock, initial lactate levels rise due to increased production and also due to reduced excretion because of compromised renal function in polytrauma patients. In trauma patients, even the usage of alcohol or any other drug by the patient does not modify the predictive accuracy of initial blood lactate levels. In patients with hepatic contusion, initial lactate level may rise.

Several arguments say that initial lactate clearance was able to predict death. The initial blood lactate level correlates well with ISS. These two variables were also able to predict early death and the need for emergency procedures like external fixator application for Damage Control Orthopaedics. These were also able to predict number of days of ICU stay, which is important because, besides mortality itself, the duration of ICU stay might be a clinically and economically relevant criterion to assess morbidity of trauma patients. These were also found to predict massive haemorrhage assessed by the need of amount of blood transfusion.

We observed less amount of complications, like septicemia, ARDS, MODS, etc., less duration of ICU stay and faster clinical recovery in patients treated in form of damage control orthopaedics concept by applying external fixator and causing minimal secondary hit to the patients with occult hypoperfusion detected by high serum lactate and low lactate clearance.

In contrast, in patients with normal vital signs, initial blood lactate and lactate clearance did not add significant additional information to that provided by trauma scores like MGAP, RTS or TRISS. Thus, it proves that although lactate clearance may be useful to assess initial resuscitation, it cannot predict occult hypoperfusion in normotensive individuals. Thus we accept the conclusion of other authors' opinion that renal artery or microcirculation blood flow should be measured to accurately detect occult hypoperfusion.

The evolution of mean blood lactate levels was significantly different in patients with normal versus abnormal blood lactate values at the time of admission[(21)]. This means that the meaning of lactate clearance may not be the same in those patients having normal lactate value at admission.

We used logistic regression method to assess the additional value of blood lactate and lactate clearance to predict mortality. Using a reclassification method, comparison of models including initial serum lactate and lactate clearance versus ISS, RTS were found to be significant, implying that these two variables significantly increase the ability of trauma scorings to predict mortality[(22,23)]. The odds ratio of initial lactate and lactate clearance are significant, using ISS as reference.

VI. Conclusion

Serum lactate at the time of admission and lactate clearance at 6 hours can be a very good prognostic factor in predicting the morbidity and mortality in polytrauma and compound fractures. Serum lactate level at the time of admission and lactate clearance during the initial hours of admission can be a good predictor of patient's progress, development of complications, need for blood transfusion, need for continued monitoring and resuscitation in ICU and chances of death of the patient. As per our observation, serum lactate can also be useful in deciding about the timing of reconstructive surgery, i.e., implementing damage control orthopaedics by applying external fixator for pelvic and long bone fractures in patients with high serum lactate but with normal vital parameters resulted in good outcome. Persistent rise in lactate indicates ongoing shock or inadequate resuscitation and heralds the presence of even an occult chest injury.

Though some of our patients with elevated initial lactate values recovered well, probably due to better resuscitation, normal lactate values at the time of admission can be a useful means to identify low-risk trauma patients. Similarly, very high lactate at the time of admission strongly predicted mortality in our study, although more sample size is needed to demonstrate the association.

Thus, a holistic approach with clinical, radiological and laboratory parameters coupled with reliable trauma scoring systems such as Injury Severity Score to guide the treatment aimed at early stabilization and mobilization of these kind of patients seem to be the emerging trend in the management of polytrauma patients.

If facilities are available, we recommend more frequent estimation of lactate, calculate lactate clearance sequentially and give more attention to the patients who show persistently high lactate values even after 48 hours of admission. Lactate clearance provides additional predictive information to initial blood lactate levels and trauma scoring systems. Hence it may be planned to use lactate values and lactate clearance in initial hours to assess the polytrauma patients to decide upon Early Total Care vs Damage control Orthopaedics and similarly in compound injury patients to decide upon early definitive fixation and temporary external fixation followed by late reconstructive surgeries.

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