Section: Orthopedics

Original Research Article

SERUM LACTATE AND BASE DEFICIT -AS A PREDICTOR OF SEVERITY OF INJURY, EARLY OUTCOMES, COMPLICATIONS, MORTALITY IN POLYTRAUMA PATIENTS

Basanna Lakkappa Saroor[1], Channareddy H[2], Palakshaiah L[3]

[1]Junior Resident, Department of Orthopedics, Basaveshwara Medical College and Hospital, Chitradurga, Karnataka, India.
[2,3]Professor, Department of Orthopedics, Basaveshwara Medical College and Hospital, Chitradurga, Karnataka, India.

Received : 29/04/2025
Received in revised form : 14/06/2025
Accepted : 02/07/2025

Keywords:
Polytrauma, serum lactate, base deficit, mortality, complications, resuscitation.

Corresponding Author:
Dr. Basanna Lakkappa Saroor,
Email: mutturaj4643@gmail.com

DOI: 10.47009/jamp.2025.7.4.32

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2025; 7 (4); 167-172

ABSTRACT

Background: Polytrauma patients often experience hypotension and hypoperfusion, leading to anaerobic metabolism, metabolic acidosis, and elevated serum lactate and base deficit (BD) levels. These markers are critical for assessing injury severity, predicting outcomes, and guiding resuscitation efforts. However, comparative studies on their predictive accuracy are limited. **Objective**: This study aimed to evaluate the prognostic value of serum lactate and BD in predicting early outcomes, complications, and mortality within 48 hours of admission in polytrauma patients. **Materials and Methods:** A prospective study was conducted on 60 polytrauma patients admitted to the Orthopedic Department of Basaveshwara Medical College and Hospital. Inclusion criteria included age >18 years and presentation within 6 hours of injury. Serial measurements of serum lactate and BD were taken at admission, 12, 24, and 48 hours. Data on demographics, injury severity (ISS), hemodynamic status, and outcomes (complications, mortality) were collected. Receiver-operating characteristic (ROC) curves were used to determine predictive accuracy. **Result**: The mean age of patients was 42 years, with 40 males and 20 females. Non-survivors (18/60) had significantly higher lactate and BD levels compared to survivors ($p < 0.05$). Prolonged normalization times for both markers were associated with increased mortality and complications - sepsis, MODS, AKI, Arrythmias, MI, CCF. ROC analysis confirmed serum lactate at 24 and 48 hours with cut off value >2.7 and 1.8 with a sensitivity and specificity of 88% ,90% and 96 % and 95% respectively. and a stronger predictor of complications and mortality than BD. Base deficit levels at 24 and 48 hours with cut off value < -3.0 and < -4.0 with sensitivity and specificity of 83%,81% and 94%,92%respectively and predicts complications. ROC curve indicates serum lactate level is a stronger predictor (>0.90) of early outcomes, complications and mortality than base deficit levels (>0.75). A higher ISS also correlated with adverse outcomes. **Conclusion:** Serum lactate and BD are reliable, independent predictors of mortality and complications in polytrauma patients. Early correction of metabolic abnormalities and serial monitoring of these markers can enhance resuscitation efficacy and improve decision-making. Arterial blood gas analysis should be prioritized for all polytrauma cases to optimize outcomes.

INTRODUCTION

In polytrauma patients, it is crucial to identify the severity of the injuries to ensure patient safety and survival.[1,2] Polytrauma leads to hypotension and hypoperfusion, which results in anaerobic metabolism with metabolic acidosis (lactic acidosis) and a decrease in base excess.[3,4] Thus, blood lactate levels above a certain threshold indicate the existence of global tissue hypoxia and multiple organ dysfunction syndrome (MODS).[5,6] The serum lactate and base deficit (BD) levels are used in polytrauma patients as measures of damage severity, resuscitation endpoints, and predictors of outcomes.[7,8] Arterial blood gas analysis is of great value in assessing the status and prognosis of patients with polytrauma.[9,10] There are few comparative studies on the predictive values of these markers in

trauma patients.[11,12] To determine which measure can more accurately predict the prognosis of polytrauma patients, the present study investigated the predictive values of lactate and base deficit as indicators of injury severity, complications, early outcomes, and mortality within 48 hours of admission to the emergency room (ER).[13,14]

Aim of the study:

To determine whether serum lactate level and base deficit in polytrauma patient correlate with early outcomes, complications and mortality

Objectives of the study

- To determine whether serum lactate level and base deficit in polytrauma patient correlate with early outcomes, complications and mortality
- To assess positive predictive value of serum lactate level and base deficit using ROC curves.

MATERIALS AND METHODS

Source of data

All patients satisfying inclusion criteria admitted in Department of Orthopedics in Basaveshwara medical college and hospital & research Centre during the period of July 2024 to October 2024 will be included in the study.

Method of data collection

- **Study design:** prospective study
- **Study period:**4 Months (July 2024 to October 2024)
- **Place of study**: Orthopedic department at Basaveshwara Medical College and Hospital. Chitradurga.
- **Sample size:** 60 (Convenience sampling)
- **Sampling technique –** Convenience sampling

Inclusion Criteria

- Polytrauma patients who have presented within 6 hours of injury
- Age > 18 years

Exclusion Criteria

Patients with

- Diabetes mellitus
- Coronary artery disease or IHD or CCF
- Renal failure
- Pregnant patients

Methodology

After obtaining approval and clearance from the institutional ethics committee, the patients fulfilling the inclusion criteria were enrolled for the study after obtaining informed consent. Polytrauma patients will be investigated with :- serum lactate and base deficit ON Day 0 (at the time of admission) ,12 hours, 24 hours, 48hours after trauma. Patients who meet eligibility criteria will be included in the study. A thorough history will be taken and clinical examination will be done. Following data collected - age, sex, hemodynamic status (BP, HR), Glasgow coma scale, Injury severity score (ISS) and Serial lactate and base deficit measurements. Serial lactate and base deficit measurements done using arterial blood gas at the time of admission, 12 hrs,24 hrs, and 48 hrs after the admission.

- Normal serum lactate levels are defined as < 2.4 mmol/L
  0 -2.4 - normal, 2.4 - 4 - moderate, > 4 - severe
- Normal base deficit levels are defined as > 0 meq/L
- >0 - normal, 0 to -6 -moderate, < - 6 - severe
- Calculating positive predictive value using ROC curve. Both groups - survivors vs non survivors, patients with complications vs without complications. Compared using serum lactate and base deficit levels with relation to severity of injury, complications, outcomes and mortality. Significance attributed to p value <0.05

Primary Outcomes

Incidence of complications

- Infections –pneumonia, sepsis, MODS
- Renal events
- Cardiac events
- Post operative wound complications
- Predictive value of serum lactate and base deficit to severity of injury, early outcomes, complications

Secondary Outcomes

- Mortality

Statistical Analysis

To evaluate differences between groups, the unpaired Student t test for continuous variables and the chi-square test for categorical variables will be used. Further, we will calculate a receiver-operating characteristic analysis and report predictive value of serum lactate and base deficit at different cut-off points. The area under the receiver-operating characteristic curve will be the overall performance measure of the accuracy of the laboratory parameter. p value of <0.05 will be considered significant.

RESULTS

The 60 polytrauma patients were included in our study. The patients serial serum Lactate, Base Deficit levels were recorded to assess their prognostic value.

Table 1: Patient demographic characteristics

Variables	Total (N=60)	Survivors(N=42)	Non survivors(N=18)	P value
Age(years) Mean age	18 to 60 42	35±10	49±10	<0.05 ,S
Gender				

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Female	20(33.3%)	8(19%)	8(44.4%)	>0.05,NS
Male	40(66.6%)	34(80.9%)	10(55.5%)	
GCS score	3 to 15	12	6	<0.05,S
ISS score	0 to 75	15	49	<0.05,S
Comorbidities HYPERTENSION COPD		2(4.7%) 1(2.3%)	4(22.2%) 2(11.1%)	>0.05,NS
Serum lactate		2.51± 1.25	6.19±2.51	<0.0001,S
Base deficit		-2.95± 5.07	-6.6± 4.51	<0.001,S

There is a significant increase in the ISS score and age and decrease in the GCS score in the non survivor group. There is a significant increase in the serum lactate levels and decrease in the base deficit levels in non survivor group compared to survivor group.

Table 2: The Mean serum lactate levels versus outcomes at various times from ER arrival

Time of lactate(hours)	Survivor lactate levels, N=42		Non –survivor lactate levels, N=18		P value
	Mean (mmol/L)	SD (mmol/L)	Mean (mmol/L)	SD (mmol/L)	
L0	4.8	3.1	6.4	3	0.069,(>0.05)NS
L12	2.4	2	4.6	3.1	**0.011,(<0.05)S**
L24	1.36	0.74	3.92	2.8	**<0.001(0.0009),S**
L48	1.21	0.54	2.24	0.8	**<0.0001(0.00004)S**

There is a significant elevation in the serum lactate levels in the non survivor group at 12 ,24 and 48 hours compared to survivor group.

Table 3: The Mean base deficit levels versus outcomes at various times from ER arrival

Time of Base Deficit(BD)-HOURS	Survivor BD levels,(N=42)		Non-survivors BD levels,(N=18)		P value
	Mean (mEq/L)	SD (mEq/L)	Mean (mEq/L)	SD (mEq/L)	
BD0	-6.4	3.6	-8	4.45	>0.05
BD-12 hours	-3.8	5.2	-6.5	4.8	>0.05
BD24	-2.24	5.4	-6.2	4.5	**<0.01**
BD48	0.62	6.1	-5.84	4.2	<**0.001**

There is a significant decrease in the base deficit levels at 24 and 48 hours in the mortality group compared to survivor group.

Table 4: The Mean and SD of mean serum lactate and base deficit of survivors versus non survivors

	Survivors(N=42)		Non-survivors(N=18)		P- value
	Mean	SD	Mean	SD	
Lactate (mmol/L)	2.51	1.59	4.19	2.42	<0.001
BD (mEq/L)	-2.95	5.07	-6.6	4.51	<0.001

There is a significant increase in the serum lactate levels and decrease in the base deficit levels in the mortality group compared to survivor group.

Table 5: Total Complications

Complications	N=33/60 (55%)
Infections	
• Pneumonia	2(3.3%)
• Sepsis	4(6.6%)
• MODS	5(8.3%)
Renal events	
• AKI	14(23.3%)
Cardiac events	
• Arrythmias	5(8.3%)
• MI	2(3.3%)
• CCF	1(1.6%)

More than half of the total patients developed complications. Acute kidney injury and infections leading to sepsis and MODS are the most common complications in polytrauma patients.

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Table 6: Mean serum lactate and BD values in patient with complications and without complications

	Without complications(n=27)	With complications(n=33)
Serum Lactate	2.9	6.2
Base deficit(mean)	4.3	6.7

P<0.05

There is a significant increase in the serum lactate levels and decrease in the base deficit levels in patients with complications.

Table 6: ROC curve analysis of serum lactate

Time Point HOURS)	S. lactate Cut off (mmol/L)	Sensitivity (%)	Specificity (%)	AUC (95% CI)	Optimal Cut off	PPV (%)	NPV (%)
L0	4.8	72.2	61.9	0.68	>5.5	45.5	83.3
L12	3.5	83.3	78.6	0.81	>4.0	62.5	91.7
L24	2.7	88.9	90.5	0.89	>2.8	**80.0**	**95.0**
L48	1.8	96.4	95.2	0.94	>2.0	**89.5**	**97.6**

The sensitivity and specificity of serum lactate level is highest at 48 hours with 96% and 94% respectively with cut off value of serum lactate >1.8.
The 24 hour cut off value of serum lactate >2.7 has 89 % sensitivity and 90% specificity for predicting complications.

Table 7: ROC curve analysis of Base Deficit values

Time Point(HOURS)	Base Deficit Cut off (mEq/L)	Sensitivity (%)	Specificity (%)	AUC (95% CI)	Optimal Cut off	PPV (%)	NPV (%)
BD0	≤-7.0	61.1	66.7	0.62	≤-7.5	45.8	78.6
BD12	≤-5.5	72.2	69.0	0.71	≤-6.0	52.0	84.0
BD24	≤-4.0	83.3	81.0	0.78	≤-4.5	**65.2**	**91.9**
BD48	≤-3.0	94.4	92.9	0.85	≤-3.5	**85.0**	**93.5**

The sensitivity and specificity of Base Deficit level is highest at 48 hours with 94% and 92% respectively with cut off value of Base Deficit <-3.0.
The 24 hour cut off value of Base Deficit level <-4.0 has 83 % sensitivity and 81 % specificity for predicting complications.

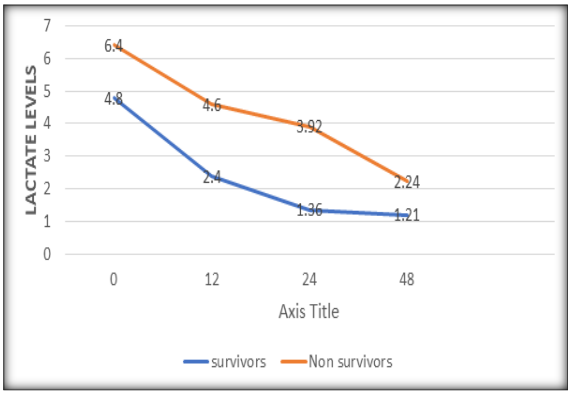

Figure 1: Serum lactate trends in survivor versus non survivors

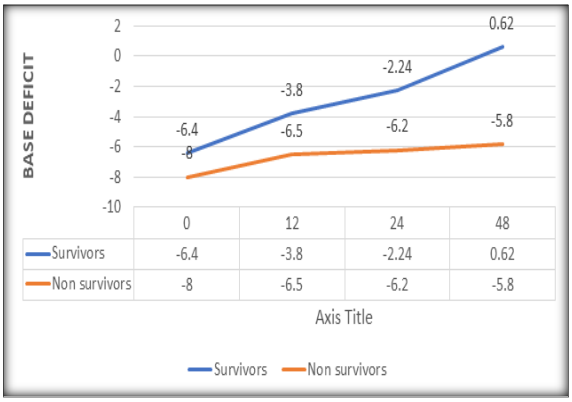

Figure 1: Base deficit level trends in survivor versus non survivors

ISSN (O): 2687-5365; ISSN (P): 2753-6556

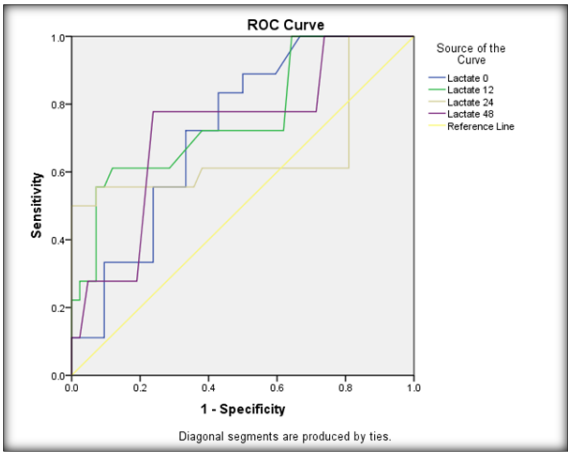

Figure 3: ROC curve of serum lactate levels

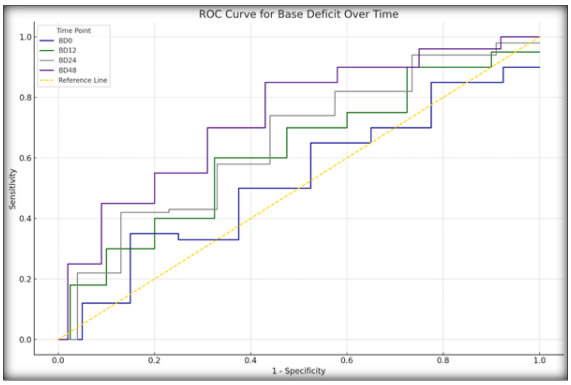

Figure 4: ROC curve of base deficit levels

DISCUSSION

This prospective study investigated the prognostic significance of serum lactate and base deficit (BD) in polytrauma patients, focusing on their ability to predict early outcomes, complications, and mortality, the findings demonstrate that both markers are valuable tools for assessing shock severity, guiding resuscitation, and improving clinical outcomes.

The serum lactate levels

The sensitivity and specificity is highest at 48 hours estimation (96.4% and 95.2%) respectively with a cut off value of 1.8mmol/L.

Serum lactate estimation at 24 hours has high sensitivity and specificity similar to 48hours estimation with values of (88.9% and 90.5%) respectively with cut off value of serum lactate 2.7 mmol/L.

These values at different timelines and cut off values as mentioned above predict complications and mortality in a patient with polytrauma.

The base deficit values

The sensitivity and specificity is highest at 48 hours estimation (94.4% and 92.9%) respectively with a cut off value of <-3.0.

Base deficit estimation at 24 hours has high sensitivity and specificity similar to 48hours estimation with values of (83.3% and 81%) respectively with cut off value of base deficit <-4.0 .

These values at different timelines and cut off values as mentioned above predict complications and mortality in a patient with polytrauma.

Area under the curve for serum lactate levels is more >0.9 compared to base deficit 0.75 levels which occupies less area under the curve. Both tests are significant predictor of early outcomes, complications and mortality but serum lactate levels is better than base deficit levels for prediction of complication and mortality.

Association with Mortality and Complications: The study revealed that non-survivors had significantly higher lactate and BD levels compared to survivors ($p < 0.05$). Prolonged elevation of these markers was strongly linked to increased complications and mortality, reinforcing their role as early indicators of poor prognosis.[15] Additionally, patients with delayed normalization of lactate and BD experienced higher rates of complications, including sepsis, MODS, acute kidney injury (AKI), and cardiac events. These findings align with prior research, such as the meta-analysis by Zhang & Xu (2014), which found that lactate levels ≥4 mmol/L and BD ≤ -6 mEq/L were strongly associated with mortality.[16]

Predictive Accuracy and Comparison Between Markers: Receiver-operating characteristic (ROC) curve analysis confirmed that serum lactate had superior predictive accuracy for mortality compared to BD, consistent with previous studies.[17] The study also found that lactate clearance—defined as a reduction in levels over time—was a critical factor in survival, supporting the concept that early metabolic correction improves outcomes.[18] However, BD remained useful, particularly in assessing the metabolic component of shock during initial resuscitation.[19]

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Correlation with Injury Severity: A higher Injury Severity Score (ISS) was associated with worse outcomes, suggesting that combining ISS with lactate/BD measurements enhances risk stratification. This aligns with existing literature indicating that severely injured patients (ISS >25) with elevated lactate have a synergistically increased mortality risk.[20]

Clinical Implications and Resuscitation Guidance: The study underscores the importance of serial lactate and BD monitoring in polytrauma patients. Early ABG analysis should be prioritized to detect metabolic abnormalities promptly.[21] Goal-directed resuscitation, targeting lactate normalization (<2 mmol/L) and BD correction (>0 mEq/L), may improve survival rates.[22] The findings also suggest that while lactate is a more reliable predictor, BD remains valuable in early shock assessment, and their combined use could enhance prognostic accuracy.[23,24]

The systematic review by Raux et al. (2017) comprehensively evaluated the prognostic value of initial blood lactate and base deficit (BD) in trauma patients through analysis of 18 studies encompassing over 15,000 patients. The study found that both biomarkers were significant predictors of mortality, but demonstrated important differences in their predictive performance. Lactate showed superior specificity for mortality prediction with an area under the curve (AUC) of 0.82 compared to 0.76 for BD, suggesting better discriminative ability to identify non-survivors. The review highlighted that admission lactate levels ≥4 mmol/L were particularly strongly associated with poor outcomes, while BD ≤-6 mEq/L served as a reliable indicator of severe shock.

CONCLUSION

In polytrauma patients, serum lactate and BD are simple, quick, and independent biochemical predictors of complications and mortality, and this single test would thereby improve decision-making for resuscitation effectiveness. Higher values of serum lactate and low base deficit are associated with increased risk of complications and mortality in polytrauma patients. Serial monitoring and early metabolic correction should be integral to trauma protocols to enhance resuscitation outcomes.

REFERENCES

1. Raux M, Le Manach Y, Gauss T, et al. Comparison of the prognostic significance of initial blood lactate and base deficit in trauma patients. Anesthesiology. 2014;120(4):988-97.
2. Abramson D, Scalea TM, Hitchcock R, et al. Lactate clearance and survival following injury. J Trauma. 1993;35(4):584-9.
3. Davis JW, Kaups KL, Parks SN. Base deficit is superior to pH in evaluating clearance of acidosis after traumatic shock. J Trauma. 1998;44(1):114-8.
4. Mutschler M, Nienaber U, Brockamp T, et al. A critical reappraisal of the ATLS classification of hypovolaemic shock: does it really reflect clinical reality? Resuscitation. 2013;84(3):309-13.
5. Vandromme MJ, Griffin RL, Weinberg JA, et al. Lactate is a better predictor than systolic blood pressure for determining blood requirement and mortality: could prehospital measures improve trauma triage? J Am Coll Surg. 2010;210(5):861-7.
6. Odom SR, Howell MD, Silva GS, et al. Lactate clearance as a predictor of mortality in trauma patients. J Trauma Acute Care Surg. 2013;74(4):999-1004.
7. Husain FA, Martin MJ, Mullenix PS, et al. Serum lactate and base deficit as predictors of mortality and morbidity. Am J Surg. 2003;185(5):485-91.
8. Paladino L, Sinert R, Wallace D, et al. The utility of base deficit and arterial lactate in differentiating major from minor injury in trauma patients with normal vital signs. Resuscitation. 2008;77(3):363-8.
9. Cerović O, Golubović V, Špec-Marn A, et al. Relationship between injury severity and lactate levels in severely injured patients. Intensive Care Med. 2003;29(8):1300-5.
10. Mikulaschek A, Henry SM, Donovan R, et al. Serum lactate is not predicted by anion gap or base excess after trauma resuscitation. J Trauma. 1996;40(2):218-22.
11. Jansen TC, van Bommel J, Mulder PG, et al. Prognostic value of blood lactate levels: does the clinical diagnosis at admission matter? J Trauma. 2009;66(2):377-85.
12. Martin MJ, FitzSullivan E, Salim A, et al. Discordance between lactate and base deficit in the surgical intensive care unit: which one do you trust? Am J Surg. 2006;191(5):625-30.
13. Rutherford EJ, Morris JA, Reed GW, et al. Base deficit stratifies mortality and determines therapy. J Trauma. 1992;33(3):417-23.
14. Manikis P, Jankowski S, Zhang H, et al. Correlation of serial blood lactate levels to organ failure and mortality after trauma. Am J Emerg Med. 1995;13(6):619-22.
15. Zhang Z, Xu X. Lactate and base deficit as predictors of mortality in trauma patients: a meta-analysis. Crit Care. 2014;18(2):R56.
16. Raux M, Le Manach Y, Gauss T, et al. Comparison of the prognostic significance of initial blood lactate and base deficit in trauma patients. Anesthesiology. 2017;126(3):522-533.
17. Jones AE, Shapiro NI, Trzeciak S, et al. Lactate clearance vs central venous oxygen saturation as goals of early sepsis therapy: a randomized clinical trial. JAMA. 2010;303(8):739-746.
18. Caputo ND, Fraser R, Paliga A, Kanter M, Hosford K, Madlinger R. Triage vital signs do not correlate with serum lactate or base deficit, and are less predictive of operative intervention in penetrating trauma patients: a prospective cohort study. Emerg Med J. 2013;30(7):546-550.
19. Rixen D, Siegel JH. Bench-to-bedside review: oxygen debt and its metabolic correlates as quantifiers of the severity of hemorrhagic and post-traumatic shock. Crit Care. 2005;9(5):441-453.
20. Caputo ND, Fraser R, Paliga A, Kanter M, Hosford K, Madlinger R. Triage vital signs do not correlate with serum lactate or base deficit, and are less predictive of operative intervention in penetrating trauma patients: a prospective cohort study. Emerg Med J. 2013;30(7):546-550.
21. Kimura A, Tanaka N. Reverse shock index multiplied by Glasgow Coma Scale score (rSIG) is a simple measure with high discriminant ability for mortality risk in trauma patients: an analysis of the Japan Trauma Data Bank. Crit Care. 2018;22(1):87.
22. Rossaint R, Bouillon B, Cerny V, et al. Management of bleeding following major trauma: an updated European guideline. Crit Care. 2010;14(2):R52.
23. Rivers E, Nguyen B, Havstad S, et al. Early goal-directed therapy in the treatment of severe sepsis and septic shock. N Engl J Med. 2001;345(19):1368-1377.
24. Jones AE, Shapiro NI, Trzeciak S, et al. Lactate clearance vs central venous oxygen saturation as goals of early sepsis therapy: a randomized clinical trial. JAMA. 2010;303(8):739-746.

ISSN (O): 2687-5365; ISSN (P): 2753-6556