Original Article

Serum Lactate –An indicator of morbidity and mortality in polytrauma and multi-trauma patients

LAMICHHANE P, SHRESTHA S, BANSKOTA B, BANSKOTA AK

B&B Hospital, Kathmandu University Teaching Hospital, Gwarko, Lalitpur, Nepal

ABSTRACT

BACKGROUND: The search for the best marker or set of markers for the diagnosis, prognosis and treatment of 'at risk' trauma patients is ongoing. Serial estimation of serum lactate values are thought to help predict morbidity and mortality in trauma victims. There is evidence to support the use of blood lactate levels as an end point of resuscitation. The presence of elevated lactic acid levels in the serum can direct the treating physician to safe and correct timing of any surgical intervention. Early identification and aggressive resuscitation measures aimed at correcting the impaired metabolic dysfunction improves survival and reduces complications in severely injured trauma patients.

METHODS: A prospective analytical study of 52 patients with polytrauma and multiple trauma admitted within 12 hours of injury to our institution between March 2007 to February 2008 was carried out. All the patients were resuscitated as per the advance trauma life support (ATLS) protocol in the emergency room. Serum lactate level was analyzed on the 1st, 5th and 14th day of injury. Serum lactate levels greater than 2 milimoles/L was considered abnormal and serum lactate level greater than 5 milimoles/L was considered significant.

RESULTS: There were 45 males and 7 females with an average age of 32.8 years (18-82). 18 patients out of 52 sustained polytrauma. Of these 18 patients, 8 patients sustained chest injury, 4 had head injury and 2 had abdominal injury. In the polytrauma group (n-18), 5 patients had an elevated lactate above 2 milimoles/L on admission. 2 patients who had significant rise of lactate (>5 milimoles/L) on admission died on the 5th day. Out of 34 multiple trauma patients, 13 patients had an elevated lactate level at admission. One patient in this group with lactate level 7.2 died of ARDS on 3rd day of admission.

CONCLUSION: Blood lactate appears to be a reliable marker reflecting not only the severity of the shock, but also for predicting survival. The longer the lactate is elevated, the more a patient is likely to develop multiple organ dysfunctions and die. Lactate levels followed over time is more reliable than isolated values.

KEY WORDS:

INTRODUCTION

It is thought that serum lactate levels help predict outcome in patients who are severely ill or injured[1] and in-hospital lactate has been shown to be a predictor of injury severity and outcome following trauma.[2]

Lactate production occurs in all tissues including skeletal muscles, brain, RBCs and kidneys even at baseline levels under normal healthy oxygen rich conditions.[3] In normal human subjects, lactate is cleared rapidly, at a rate of about 320 milimoles per litre per hour, mostly by liver metabolism and by reconversion of lactate back to pyruvate. This helps keep basal arterial and venous lactate levels below one milimole per litre.[3] In a scenario of inadequate tissue perfusion, anaerobic metabolism prevails whereby pyruvate is metabolized to lactate, ultimately generating fewer adenosine triphosphate (ATP) molecules (2 vs. 36) than through the normal aerobic mechanism via the tricarboxylic acid cycle pathway.[3] Persistent lactic acidosis is associated with

higher rates of respiratory failure, multiple system organ failure and death after severe trauma or polytrauma. Thus, lactic acidosis may signal the presence of overt or occult pulmonary tissue injury, resulting in increased morbidity and mortality in patients with musculoskeletal trauma.[3] This study signifies whether increased serum lactate has any deleterious effect in outcome in poly trauma and multiple trauma patients.

MATERIALS AND METHODS

A prospective analytical study of 52 patients admitted to our institution between March 2007 and February 2008 was carried out. An informed consent was taken from all the patients and their respective patient parties. Multiple trauma and poly trauma patients admitted within 12 hours of injury were included. Patients whose initial lactate levels were not recorded and who came late (12 hours of injury) were excluded. All patients were resuscitated as per the advance trauma life support (ATLS) protocol in the emergency room. Blood samples were taken from the radial artery and blood gas analysis was performed. Serum lactate levels were sent on admission and repeated on the 5th and 14th days for all patients and daily for those patients who had an elevated value on admission. Serum lactate level >2 mmoles/litre was considered to be abnormal and >5 mmoles/litre was considered significant. Definitive management of fractures was undertaken only after the serum lactate was normal in all the patients.

RESULTS

There were 45 males and 7 females with an average age of 32.8 years (18 to 82).Eighteen of the 52 patients sustained polytrauma, defined as bony injury coupled with one or more major system involvement. Of these, 8 patients sustained a chest injury, 4 patients had a head injury, 2 had an abdominal injury, one patient each had a combination of head plus chest and chest plus abdominal injury respectively and 2 had a combination of head and abdominal injury. Of the bony injuries in this group, 11 had a femur fracture, 7 had a tibia fractures (1 bilateral), 2 had a pelvis fractures and 1 had a spine fracture. A complete breakdown of system involvement and associated fractures in each of the 18 patients is given in Table 2.

Table 1: Breakdown of systemic injuries in polytrauma patients

INJURIES			NO.
Lung (L)	Contusion (C)	5	8
	Hemothorax (He)	2	
	Blunt Chest Trauma (B)	1	
Head, Contusion H (CO)			4
Abdomen, Splenic Rupture A (Sp)			2
Head Contusion H (CO) + Lung, Blunt Chest Trauma L (B)			1
Lung, Hemothorax L (He) + Abdomen, Blunt Abdominal injury A (Blu)			1
Head (H) + Abdomen (A)	Head Contusion H (CO) + Abdomen (Splenic Rupture) A (Sp)	1	2
	Head Contusion H (CO) + Abdomen (Bladder Injury) A (Bl)	1	

Table 2: Polytrauma patients (n=18) with their bony and systemic injuries and lactate values on admission, at day 5 and day 14

SN	FEMUR	TIBIA	HUMERUS	RADIUS / ULNA	PELVIS	SPINE	OTHERS	OTHER SYSTEMS	LACTATE 1	LACTATE 5	LACTATE 14
1		+ Open					Scapula Fibula	L (C)	0.9	1.6	1.3
2		+						L (He)	3	0.9	1
3			+	Ulna				L (C)	0.9	0.9	0.3
4	+	+						H (CO)	3.2	1.4	1.5
5	+	+						L (C)	0.9	1.6	1
6			+		+	+	Ribs	L (He)	1	0.9	0.7
7	+							H (CO)	0.9	0.9	0.9
8		+		Radius			Talus MC	H (CO)	1.3	0.9	0.5
9	+				+			L (He), A (Blu)	0.8	1.3	1.2
10	+	+					MT	H (CO), A (Bl)	2.7	1.3	1.9
11			+	Both Bone			Scapula	L (B)	0.9	1.3	1.2
12	+ open			Radius				H (CO), L (B)	8.5 5.5*	DEATH	
13		+ Open Bilateral					Foot	A (SP)	0.8	0.8	0.5
14	+		+	Radius				H (CO)	1.8	1.6	1.5
15	+						Clavicle	H (CO), A (Sp)	7.6 6.0*	DEATH	
16	+						Talus Navicle	A (Sp)	1.2	1.3	0.9
17	+							L (C)	1.2	0.9	2.3
18	+							L (C)	1.1	1.1	1.1

+ Patient sustaining injury , * Lactate at 48 hours

Of the 52 patients in our study, 34 patients had multiple trauma defined as a combination of two or more major bony injury. In this group, 25 patients had a femur fracture (3 bilateral), 20 had a tibia fracture (3 bilateral), 9 patients had a pelvis fracture and 1 had a spine fracture in association with other bony injuries. A complete breakdown of the combination of fractures in the multi trauma group is shown in Table 3.

Table 3: Multi-trauma patients (n= 34) with their bony injuries and lactate values on admission, day 5 and day 14

SN	FEMUR	TIBIA	HUMERUS	RADIUS / ULNA	PELVIS	SPINE	OTHERS	LACTATE 1	LACTATE 5	LACTATE 14
1		+ B/L		Ulna		+		3.3	1.5	2.4
2			+		+		Clavicle	1.4	1.5	1.6
3			+		+			2.6	1.2	1.2
4	+	+						3.9	0.8	0.8
5	+				+		Patella	2.4	1.8	1.1
6		+ B/L		Ulna				0.7	1.5	0.9
7	+ B/L			Both Bone				7.2	DEATH	
8	+ B/L	+					Patella	0.9	1.2	1
9				Both Bone	+			1.9	1.2	0.1
10	+	+						4	1.1	0.9
11	+	+					Medial Malleolus	3.5	0.8	0.9
12		+						4.9	0.9	0.9
13	+							1.8	5.4	1.7
14	+							2.1	0.9	1.5
15		+					Scapula Ribs	1.2	0.9	2.3
16	+	+ B/L						3	0.9	0.9
17		+ pen			+			1.2	0.8	0.9
18	+	+					Patella	0.8	1	0.9
19	+	+						0.2	0.8	0.9
20	+			Radius			Right Hip dislocation & Left Knee dislocation	0.8	0.8	1.1
21	+	+						1.1	DEATH	
22	+ Open							1.8	4.5	1.5
23	+ Open	+						2.4	1.1	1.8
24	+				+		Neck of Femur	2.6	1.7	1.1
25	+				+			0.8	0.9	1.1
26	+	+		Radius				0.8	1.7	1.4
27	+	+						1.9	0.7	1.1
28	+	+		Both Bone				1.7	1.1	1.9
29	+				+			0.7	0.8	0.9
30	+							1.8	0.8	0.6
31		+			+			0.9	0.8	1.1
32	+						Neck of Femur	1.4	1.4	1.2
33	+ B/L	+						1.2	0.9	2.3
34	+	+						4	0.9	0.9

+ Patients sustaining injury

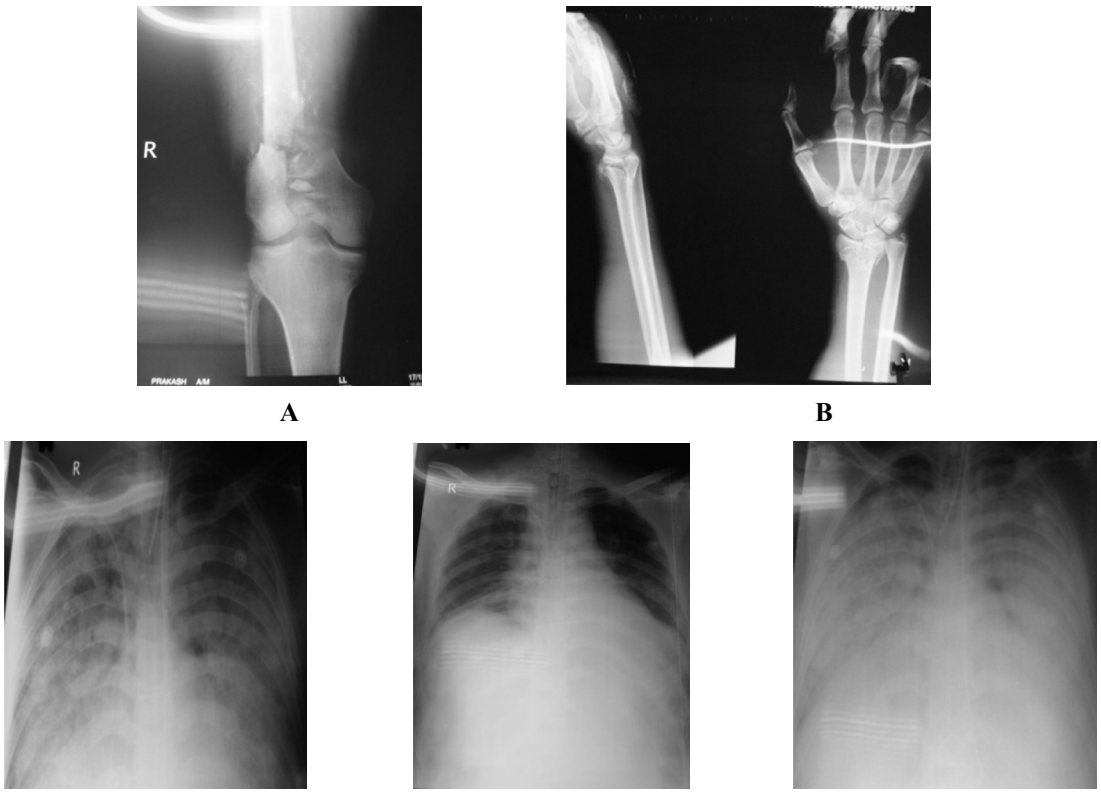

Fig 1. Roentgenograms of a 32 years old male who sustained blunt chest trauma and head contusion, an open comminuted supracondylar fracture of the right femur (A) and a right distal radius fracture (B) following a high velocity motorbike accident. His chest x-ray on admission was essentially normal (C) but subsequently showed features of full blown ARDS over the next two days (D, E and F). He died of respiratory failure on the fifth day of admission. His lactate value was 8.5 milimoles per litre on admission and was 5.5 in 48 hours.

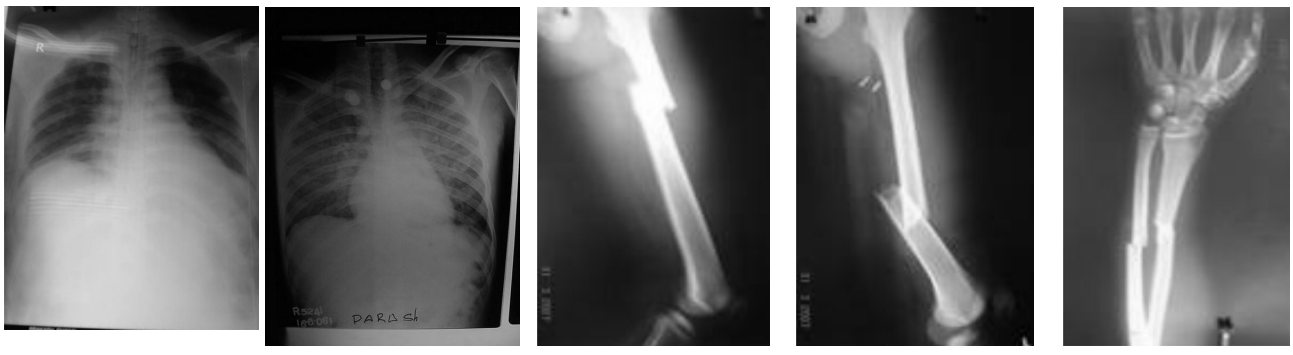

Fig 2. Roentgenograms of 28 years male who sustained bilateral shaft of femur fracture (C & D), both bone fracture of right forearm (E). His Chest X-ray on admission was normal (A) but showed features of ARDS 48 hours later (B). His serum lactate on admission was 7.2 and at 48 hours was 6. He died of respiratory failure on third day of admission.

In the polytrauma group (n=18), 5 patients (27.8%) had an elevated lactate level (> 2 mmols/l) on admission. This included hemothorax with closed tibia fracture in one (lactate=3), head injury with closed femur and tibia fracture in one (lactate=3.2), head plus abdominal injury with closed femur and tibia fracture (lactate=2.7), head plus chest injury (blunt chest trauma) with open femur and radius fracture (lactate=8.5), head plus abdominal injury with closed femur and clavicle fracture (lactate=7.6). Two of these patients died of respiratory failure on the fifth day of admission. Their lactate levels were 8.5 and 7.6 on admission respectively and remained elevated at 48 hours (5.5 and 6.9 respectively). Table 2 shows details of lactate values in this group of patients. There were 2 mortality in the polytrauma group (n=18) and 2 mortality in those with elevated lactate on admission (n=5).

In the multiple injury group (n=34), 13 patients (38.3%) had elevated lactate on admission. Five of them had values between 2–3, four were between 3–4, three were between 4–5 and one patient had a value of 7.2. This last patient (lactate = 7.2) had bilateral closed femur fractures and died of ARDS on the third day following admission; his lactate at 48 hours was 6.0. Table 3 gives details of lactate values in this group of patients. The overall mortality in the multi trauma group (n=34) was 5.9% and mortality in those with elevated lactate on admission (n=13) was 7.7%. One patient died on day 5 inspite of a normal lactate (1.1) on admission. The average time to surgery in patients with elevated lactate on admission was 7.9 days (2-42) when the physiology of patient was stable.

DISCUSSION

The literature has reports both for and against the utility of serum lactate values in predicting survival following major injury. Several studies have found elevated lactate levels to be very useful in prognosticating polytrauma and multiple trauma patients, particularly in those with an associated lung injury.[1,3,4,5] In a prospective study of 5995 patients admitted to the trauma registry of a university, Pal et al. did not find the admission lactate levels to be predictive of mortality in the severely injured patient.[6]

Elevated lactate levels reflect tissue hypoxia and ongoing anaerobic metabolism in the body and are usually overcome with adequate resuscitation. Persistent rise in serum lactate is an indicator of ongoing shock or inadequate resuscitation. It can also herald the presence of an occult chest injury.

Blood lactate levels start rising as early as thirty minutes following injury.[2] Normal lactate values can vary slightly with age and whether arterial or venous samples are used. In a study of 375 patients, Lavery et al found no difference in the mean arterial and venous lactate levels.[7] Significant lactic acidosis is present if blood lactate concentration rises more than five milimoles per litre and the blood Ph falls less than 7.35.[1] Serial measurements of serum lactate seem to be more prognostic as opposed to isolated values.[3,8]

Manikis et al studied 129 patients admitted to ICU and found that there was a significant difference in the mean lactate levels in survivors (2.4) as compared to non-survivors (4).[9] 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.[10] Following major trauma, there is a surge of pro-inflammatory mediators, notably interlukin-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 at 6 to 8 days fared better than those operated between 2 to 4 days with respect to development of multi-organ failure.[11]

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.[1,7,8] 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.[12]

Persistent lactic acidosis is associated with higher rates of respiratory failure and multiple system organ failure and death after severe trauma.[3] In our study, mortality rate for

polytrauma patients with an elevated lactate on admission was a staggering 40% whereas that for multi-trauma patients with elevated lactate on admission was 7.7%. All these patients eventually succumbed to acute respiratory distress syndrome (ARDS) and multiple organ failure.

In our series, patients who had significant rise of serum lactate (>5 milimoles/L) at admission and remained elevated throughout had worse prognosis than whose lactate was significantly high at admission and normalized rapidly with in 24-48 hours. Severity of injury and serum lactate levels were also more on patients with occult lung injury. We couldnot include all the patients with multiple and poly trauma admitted at that period since some arrived late to the hospital and their initial lactate levels couldnot be estimated. Sometimes there was technical error with the ABG analyzer.

Though this is a small series of study we conclude that serum lactate can be a useful marker for identifying and monitoring resuscitation and treatment and prognosticating morbidity and mortality in the polytrauma or multi-trauma patient. Although further studies are required to identify the precise significance of elevated lactate levels in predicting survival in multi-trauma patients, normal values on admission can still be a useful means to identify the 'low risk' trauma patient. A holistic approach considering clinical, laboratory and radiological parameters coupled with scoring systems such as the injury severity score (ISS) to guide treatment aimed at early stabilization and mobilization seems to be the emerging trend in the management of this challenging category of patients.

If facilities are available, we recommend serum lactate estimation sequentially in polytrauma and multiple trauma patients. More attention should be given to patients whose serum lactate is persistently high up to 48 hours and also in those with occult chest injury.

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CORRESPONDENCE:
Dr. Pramod Lamichhane
B&B Hospital PO 2481, Gwarko
E-mail: drpramod131@gmail.com