EGYPTIAN JOURNAL OF ANAESTHESIA
2023, VOL. 39, NO. 1, 149–156
https://doi.org/10.1080/11101849.2023.2175871

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Study of initial blood lactate and delta lactate as early predictor of morbidity and mortality in trauma patients

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ABSTRACT

Background: It has been demonstrated that lactate is a predictive indicator in trauma. It is yet unclear how non-normalization of lactate affects trauma victims.

Methods: In trauma patients, blood lactate levels were measured at admission and every 2 hours after that. A multivariate logistic regression analysis was conducted to identify the crucial variables to evaluate hospital mortality risk factors.

Results: 519 patients with trauma were assessed. Male patients (79%, n = 409) who were mostly young (42±20 years old) and had no comorbidities (ASA 1) made up the majority of the patient population. Patients who had normalization of serum lactate in the first 24 hours represented 76% (n = 392) of all trauma patients. Male patient status (OR = 2.2 (1.1–4.6)) and blood alcohol level (OR = 0.64 (0.44–0.91)) were independently linked in a logistic regression model with the failure of serum lactate to normalize in trauma patients over the initial 24 hours. Three variables were independently associated with hospital mortality: a GCS >9 (OR = 0.78 (0.61–0.96)), and a pH> 7.37 (OR = 0.0028(0.00066–0.52)) at admission were protecting factors. One of the main risks for death in the pre-field was cardiorespiratory arrest (OR = 62 (2.2–4400)). Hospital mortality was not related to non-normalization of serum lactate in the initial 24 hours (OR = 1.8(0.4–7.9)).

Conclusions: Although serum lactate at admission is associated to trauma patient prognosis, our study failed to show that non-normalization of serum lactate in the initial 24 hours was a factor that could predict hospital mortality. A future study focusing on normalizing serum lactate in a shorter scale of time could be interesting.

ARTICLE HISTORY
Received 24 December 2022
Revised 1 January 2023
Accepted 29 January 2023

KEYWORDS
Lactates; patient prognosis; trauma

1. Introduction

The third leading cause of death is trauma, representing 10% of death in the world [1]. The majority of deaths in people under the age of 40 are caused by it, and is responsible for heavy handicaps [2]. Additionally, the risk of death is rising among a growing number of elderly trauma patients [3]. One of the two leading causes of death following trauma is hemorrhage, and the majority of deaths (80%) take place within 48 hours [4]. Thus, it is essential for the trauma system to provide early tailored care and correct triage, matching resources to the degree of the patient's injuries without overloading the system. The first decision made during triage is whether to take a patient to a trauma center. Many scores are used in trauma to predict the hospital mortality; The level of tachycardia with hypotension is frequently overestimated, and the metabolic alterations brought on by trauma are frequently underestimated. The pre-hospital phase triage uses the RTS and MGAP scores since they are readily available and serve as indicators of hospital mortality. RTS, at least in its triage version, is the most popular score [5,6]and In comparison with RTS, MGAP has lately been demonstrated to be a more precise and easier-to-use score [7]. Because TRISS has specific data about trauma lesions, it was chosen as the reference standard [8]. It should be noted that all of the variables used to compute the TRISS score are related to events that occurred before to hospital admission, even though the TRISS score is only calculated once all information regarding trauma lesions has been acquired (age, type of trauma, RTS, ISS). Numerous studies advise that anatomical and physiologic parameters be used to determine the greatest level of trauma activation [9]. While low levels of activation heavily overlap field triage criteria and high-risk cause of injury criteria [10]. Traditional vital signs, which measure tissue perfusion, are specific but not highly sensitive indicators of hemorrhage, whereas metabolic parameters, such as initial serum lactate and its variation, are extremely accurate markers of blood loss and may be used as prognostic indicators in trauma patients. Therefore, serum lactate may be helpful in identifying significant and small injuries in trauma

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patients with normal vital signs [11]. Thus, the target in early trauma management is not only the diagnosis and treatment of trauma consequences but also, assessing the predictors of a good response to this early management [12].

Moreover, early bleeding detection and treatment are the primary principles of trauma patient care. For these patients, limiting the effects of shock is a recurring difficulty. Inadequate oxygen delivery, coagulopathy, the onset of infection, and organ failures are all made more likely by hypoperfusion and shock, which also causes tissue hypoxia, anaerobic metabolism, lactate generation, and ultimately late hospital death [13]. It has been claimed that up to 85% of seriously injured patients undergoing trauma treatment still display insufficient tissue oxygenation even after the traditional resuscitation criteria, such as normal systolic and diastolic pressure, cardiac frequency, and urine output, have been restored [14]. As a result, it is advised to stratify patients depending on their need for continuing fluid resuscitation and to use the measurement of serum lactate as a marker to identify patients who need early aggressive resuscitation. An evaluation of hemoglobin solutions in trauma patients in a randomized trial included lactate clearance as a primary outcome [15]. In a prior investigation on trauma patients, the authors found that Results of acute hemorrhagic shock are connected with normalization of serum lactate within 8 hours or clearance of more than 20% within 2 hours (i.e., equal to 40%/h) in patients with high initial blood lactate levels (more than 5 mM/l) [15]. However, most of those studies focus on the initial few hours and use complicated formulas, making it difficult to use at the bedside [14]. Thus, a simple tool: non-normalization of serum lactate in the first 24 hours could be a simple tool to predict hospital mortality and/or morbidity and guide resuscitation.

It was hypothesized that, patients with non-normalization of lactate in the first 24 hours would have significant increases in hospital mortality rates.

The purpose of this retrospective observational study was to evaluate the significance of serum lactate levels in trauma patients not reverting to normal during the first 24 hours. We aimed to determine the association between non-normalization of serum lactate the initial 24 hours and mortality in hospitals in trauma patients. And so, we can detect other indicators of death in the initial 24 hours and as result we can detect the predictors of serum lactate not returning to normal in the first 24 hours.

2. End points

We can explain the additional characteristics related with hospital death in our trauma patients because In-hospital mortality was the main outcome measure.

Finally, we evaluated the characteristics that increase the likelihood of patients' serum lactate not normalizing during the first 24 hours.

3. Materials and methods

From October 2018 to October 2019, this monocenter observational study was carried out in a French academic trauma center (equivalent to a level-1 trauma center). A trauma registry used at the Hôpital Nord in Marseille provided data that was collected prospectively. This registry (Traumabase®, traumabase.eu) is shared between 16 trauma centers in France. This registry has the approval of the local ethics committee and the national Commission on Informatics and Liberties (CNIL 911461) as well as the advisory Committee for Information Processing Health Research (CCTTIRS 11.305bis).

In France, a dispatching physician working out of a centralized call center makes the decision regarding whether emergency vector should be used (paramedic staffed or physician-staffed). After onsite triage, patients are sent to a trauma center because the pre-hospital team believes they have suffered serious trauma and they need to be treated there. All patients brought to the trauma room at Hôpital Nord were recorded in the registry.

Only the data from Hôpital Nord were used in this analysis, and clinical, biological, and treatment information (from the pre-hospital phase until discharge from the critical care unit) were thoroughly gathered.

Each patient received to the study hospital had their pre-hospital period data, which included the type of injury, initial systolic arterial blood pressure, heart rate, respiratory rate, Glasgow coma scale, peripheral oxygen saturation, and resuscitation care provided during the pre-hospital phase (mechanical ventilation, total amount of crystalloids and/or colloids given, initial hemoglobin, and serum lactate), recorded. Routine radiological exams and biochemical assays (hemoglobin, arterial blood gases, serum lactate, creatinine, and fibrinogen) were documented. At arrival and at least once more within the first 24 hours, serum lactate levels were assessed. In our hospital, a normal serum lactate level is 1.8 mmoles/L. Serum lactate normalization was defined as normalizing within the first 24 hours of treatment or if the level was normal upon arrival. A non-normal value of serum lactate after 24 hours of care was referred to as non-normalization of serum lactate (whether serum lactate rose or did not normalize). The time between the emergency team's arrival on the site and its arrival at the hospital was referred to as the "total pre-hospital time." The scores shown below were calculated: Abbreviated Injury Scale (AIS), Injury Severity Score (ISS), American Society of Anesthesia (ASA), Revised Trauma Score (RTS), Simplified Acute Physiology Score (SAPS II) and Sequential Organ Failure Assessment (SOFA).

The Trauma Related Injury Severity Score was then used to determine the likelihood of survival (TRISS). The length of hospital and ICU hospitalizations, as well as complications that developed during this time, were noted.

4. Statistical analysis

According to their distribution, continuous data are reported as mean ± SD or median (quartile 1; 3). Data that is categorical is expressed as counts and percentages. Depending on the normality of the data, comparisons of continuous data were done using the Student t Test, non-parametric Mann-Whitney test, or Kruskal-Wallis test. Using Fisher's exact test, proportion comparisons were done.

A multivariate logistic regression analysis was carried out in order to identify the critical variables to consider when assessing hospital mortality risk factors. A stepwise variable selection model includes significant parameters with $p < 0.2$ in univariate analysis. A value of $p < 0.05$ was used as the final significance threshold.

The statistics were done with the R-Project 3.4.4 software for Linux Ubuntu.

5. Results

519 trauma patients were admitted in Marseille Hôpital Nord Trauma Center during the study period. Description of trauma population is summarized in Table 1. Patients were mainly young (42±20 years) male patients (79%, n = 409), with no comorbidities (ASA 1). Road traffic accidents were the most common cause of injury (63%). Most patients were subsequently admitted to the trauma hospital (primary origin (n = 392, 75.97%)). Hospital mortality rate was 12%. 10% of trauma patient had massive hemorrhage, 34% brain trauma. 76% (n = 392) of all trauma patients obtained serum lactate normalization within the first 24 hours.

A univariate analysis of factors that were associated with death was performed. Results are exposed in Table 2. Non-normalization of serum lactate was a risk factor for death ($p = 0.005$). Among the numerous elements linked to hospital mortality were older age ($p < 0.001$), poorer clinical condition during pre-hospital phase (lower systolic blood pressure ($p < 0.001$) lower initial GCS ($p < 0.001$), lower peripheral oxygen saturation ($p < 0.001$), catecholamine administration ($p < 0.001$), use of mechanical ventilation ($p < 0.001$). Lower hemoglobin ($p < 0.001$) and low PH ($p < 0.001$) were also associated with hospital mortality. To note, orthopedic surgery ($p = 0.05$) and neurosurgery ($p < 0.001$) were also associated with hospital mortality.

a multivariate logistic regression was performed after selecting factors commonly cited for poor outcome after traumatic injury and that were risk factors for death in our univariate analysis (sex, pre-hospital cardiorespiratory arrest, systolic pressure $_{min}$, diastolic pressure $_{min}$, pre-hospital hemoglobin, pre-hospital intubation, PH, platelets level, fibrinogen level, whether is on catecholamine or not, initial Glasgow Coma Scale [GCS $_{initial}$], as well as emergency procedures on admission) . Hospital mortality was independently correlated with three different factors: a GCS >9 (OR = 0.78(0.61–0.96)), and a pH> 7.37 (OR = 0.0028 (0.00066–0.52)) at admission were protecting factors. Cardiorespiratory arrest in the pre-field was a major risk factor for death (OR = 62 (2.2–4400)). Non-normalization of serum lactate in the initial 24 hours was not associated with hospital mortality (OR = 1.8 (0.4–7.9)) as shown in Table 4.

The univariate analysis of the factors associated with normalization of serum lactate in the first 24 hours is displayed in Table 3. Patient who did not normalize serum lactate in the first 24 hours were more likely to be men ($p = 0.004$), and had lower systolic arterial blood pressure ($p = 0.005$), lower hemoglobin levels ($p < 0.001$) with massive hemorrhage ($p < 0.01$), had more emergency procedure ($p < 0.001$). Moreover, gravity scores were also higher (SAPS II, SOFA, ISS, RTS, and TRISS). Blood alcohol level was also higher ($p < 0.001$).

In logistic regression model as shown in Table 5, being a male patient (OR = 2.2 (1.1–4.6)) and the blood alcoholic level (OR = 0.64 (0.44–0.91)) were independently associated with the non-normalization of serum lactate during the first 24 hours in trauma patients.

6. Discussion

Our study population that is described in Table 1 is not different from other trauma population. Indeed, for instance the German register "Traumaregister DGU™" described its population as male patients (71.6%), with a hospital mortality of 11.5%, 34% of brain trauma [16]. In the national French registry "Traumabase", male patients were 78% with a medium ISS of 14, hospital mortality was 10.8% [17]. Lastly, a comprehensive analysis of the effect of trauma-center care on hospital mortality was conducted in the United States, revealed that the trauma population was primarily made up of men (73%) and that hospital mortality ranged between 10 and 13% [18].

As early 1993, Abramson and colleagues showed that in a group of 76 patients with multiple traumas, all patients who had a normal serum lactate level in 24 hours survived. The survival rate was 77.8% if blood lactate levels returned to normal in between 24 and

Table 1. Characteristics Of trauma Patients.

	N = 519	Missing data (N)
Men	409(79.1%)	0
Age, years	42 ± 20	0
Mechanism of trauma		0
Fall	104(20%)	
Road Crash	326(63%)	
Gunshot	23(4%)	
Stab wound	27(5%)	
Other	39(8%)	
Origin of patient		3
Primary	392(76%)	
Secondary	84(16%)	
Emergency room	40(8%)	
Pre-hospital phase		
Systolic arterial blood pressure min, mmHg	105±36	81
Heart rate max, Beats/min	98±28	83
Glasgow Coma score	14(8–15)	0
Peripheral Oxygen saturation min, %	97(91–100)	23
Cardiac arrest	20(4%)	0
Catecholamine administration	70(14%)	14
Mechanical ventilation	162(32%)	7
Time taken to reach the scene, minutes	17±11	181
Time taken to reach the hospital, minutes	59±58	158
ASA1	1(1–2)	0
Initial lactate	2.89 ± 3.20	102
Lactates at 2 hrs	3.69 ± 3.71	427
Lactates during first 24 hrs	2.05 ± 1.75	300
Hospital phase		
Systolic arterial pressure, mmHg	123±29	31
Heart rate, beats/min	89±23	30
Hemoglobin, g/dl	12.63±2.22	19
Blood alcohol level, g/dl	0.32±0.72	0
Results of FAST		95
Positive	102(24%)	
Open fracture	84(17%)	21
Surgery or interventionnel direct	23(4%)	135
Emergency procedure	226(44%)	0
Neurosurgery	53(10%)	0
Orthopedic surgery	108(21%)	0
Thoracic surgery	11(2%)	0
Visceral surgery	41(8%)	0
Radiologic intervention	20(4%)	0
Vascular surgery	20(4%)	0
Other surgery	17(3%)	0
Massive hemorrhage2	54(10%)	0
Cranial trauma	178(34%)	0
Duration of stay in the ICU, days	3(2–6)	1
Duration of stay in the hospital, days	9(5–17)	91
Death	61(12%)	0
Cause of death:		
Brain death	19(31%)	
Cranial trauma	15(25%)	
Hemorrhagic shock	4(7%)	
Limitation of life sustaining treatment	9(15%)	
Multiple organ failure	9(15%)	
Others	5(8%)	
SAPS II3	32(21–49)	0
SOFA4	3(0–6)	87
ISS5	16(9–25)	118
RTS6	7.84(5.97–7.84)	115
TRISS7	0.03(0.01–0.15)	200
Normalization of lactate	392(76%)	1

1, American Society of Anesthesia, 2, transfusion of more than or equal to 4 PRBCs within 6 hours, 3, Simplified Acute Physiology Score, 4, Sequential Organ Failure assessment, 5, Injury Severity Score, 6, Revised Trauma Score, 7, Trauma Related Injury Severity Score

48 hours, and only 3 of the 22 patients whose serum lactate levels had not returned to normal by 48 hours had survived. They found that among patients with serious injuries, the time period it took for serum lactate levels to return to normal was a significant predictive predictor for survival.

Dezman and colleagues [19] in 2015 showed that after injury, failure to eliminate serum lactate was a reliable indicator of poor prognosis. Indeed, 24 hours hospital mortality was nearly seven times higher than in the patients who normalized their serum lactate levels. In the present study, non-

Table 2. Comparison of Patients who survived or not.

N = 519	Dead (n = 61)	Alive (n = 458)	P value
Men	43 (11%)	366 (89%)	NS
Age, yr	52±22	40±19	<0.05
Mechanism of trauma			<0.05
Fall	21(35%)	83(18%)	
Road Crash	35(58%)	291(63%)	
Gunshot	2(3%)	21(5%)	
Stab wound	0	27(6%)	
Other	3(4%)	36(8%)	
Origin of patient			NS
Primary	47(77%)	345(76%)	
Secondary	12(20%)	72(16%)	
Emergency room	2(3%)	38(8%)	
Pre-hospital phase			
Systolic arterial blood pressure min, mmHg	72 ± 63	110±27	<0.05
Heart rate max, Beats/min	86 ± 48	100 ± 25	<0.05
Glasgow Coma score	3(3–8)	15(12–15)	<0.05
Peripheral Oxygen saturation min, %	90(80–98)	97(92–100)	<0.05
Cardiac arrest	19 (31%)	1 (0.2%)	<0.05
Catecholamine administration	32(54%)	38(9%)	<0.05
Mechanical ventilation	51(85%)	111(25%)	<0.05
Time taken to reach the scene, minutes	15(10–20)	15(10–20)	NS
Time taken to reach the hospital, minutes	52(30–84)	45(25–77)	NS
ASA	2(1–3)	1(1–2)	<0.05
Hospital phase			
Systolic arterial pressure, mmHg	106 ± 50	125 ± 24	<0.05
Heart rate, beats/min	84 ± 39	90 ± 21	<0.05
Hemoglobin, g/dl	10.69 ± 2.62	12.88 ± 2.04	<0.05
Blood alcohol level, g/dl	0.28 ± 0.72	0.32 ± 0.72	NS
PH	7.16 ± 0.23	7.35 ± 0.10	<0.05
FAST results			NS
Negative	33(70%)	289(77%)	
Positive	14(30%)	88(23%)	
Open fracture	9 (16%)	75 (17%)	NS
Surgery or interventional direct	5(11%)	18(5%)	NS
Emergency procedure	22(36%)	204(45%)	NS
Neurosurgery	11 (18%)	42 (9%)	0.05
Orthopedic surgery	2 (3%)	106 (23%)	<0.05
Thoracic surgery	1 (2%)	10 (2%)	NS
Visceral surgery	8 (13%)	33 (7%)	NS
Radiologic intervention	5 (8%)	15 (3%)	NS
Vascular surgery	1 (2%)	19 (4%)	NS
Other surgery	0 (0%)	9 (2%)	NS
Massive hemorrhage	16 (26%)	38 (8%)	<0.05
Cranial trauma	45 (74%)	133 (29%)	<0.05
Duration of stay in the ICU, days	2 (2–7)	3 (2–6)	<0.05
Duration of stay in the hospital, days	2(2–7)	10(6–19)	<0.05
SAPS II	30(19–46)	40.5 (28.25–60.75)	<0.05
SOFA	10 (8–11)	2 (0–5)	<0.05
ISS	26(25–41)	16(9–22)	<0.05
RTS	4.09 (1.16–5.03)	7.84 (6.38–7.84)	<0.05
TRISS	0.73 (0.37–0.87)	0.02 (0.01–0.09)	<0.05
Normalization of lactate in 24 hr	37(61%)	355(78%)	<0.05

normalization of serum lactate in the first 24 hours was associated to trauma patient prognosis, but not a risk factor to predict hospital mortality. This could be that we chose to keep patients with normal serum lactate at arrival in our analysis, making it maybe a too much heterogeneous population for any conclusion. Moreover, maybe that clearance of serum lactate was defined in a too wide time scale i.e., 24 hours: Marie-Alix Régnier and colleagues [15] demonstrated that if serum lactate clearance was calculated within the initial 2 h after admission it was an independent prognostic factor. In this same study, serum lactate clearance in between 2 and 4 hours after arrival failed to demonstrate any correlation with prognosis. Indeed, Initial serum lactate and serum lactate clearance did not significantly supplement the data provided by MGAP, RTS, or TRISS in normotensive individuals, even when a potent technique like reclassification was employed. This significant negative finding indicated that, while serum lactate clearance may be helpful to evaluate the initial resuscitation given to trauma patients, it is probably not adequate to diagnose occult hypo-perfusion [20,21].

In our study, a GCS underneath 9, a predictor of hospital mortality that was discovered. This is not different from other studies: Lodge CJ and colleagues [22], investigated 1167 patients in UK and reported an overall hospital 30-day hospital mortality rate of 12.9%(n = 150). Patients with a GCS of 13 or lower at presentation had a hospital mortality rate of 60.7%, while those with a GCS of 13 to 15 had a hospital mortality rate of only 9.8%. Moreover, it highlights

Table 3. Comparison of patients with normalization of lactate or not in the 24 first hours.

N = 518	Normalization of lactate (n = 392)	Non normalization of lactate (n = 126)	P value
Men	321 (79%)	87 (21%)	<0.05
Age, yr	42 ± 20	40±18	NS
Mechanism of trauma			NS
Fall	82	22	
Road Crash	239	87	
Gunshot	17	6	
Stab wound	25	2	
Other	30	9	
Origin of patient			NS
Primary	288(74%)	103(26%)	
Secondary	65(77%)	19(23%)	
Emergency room	37(93%)	3(7%)	
Pre-hospital phase			
Systolic arterial blood pressure min, mmHg	107 ± 34	96 ± 40	<0.05
Heart rate max, Beats/min	98 ± 26	100 ± 34	NS
Glasgow Coma score	15(10–15)	13(6–15)	<0.05
Peripheral Oxygen saturation min, %	97(92–100)	96(88–100)	<0.05
Cardiac arrest	11 (3%)	9 (7%)	0.05
Catecholamine administration	43(11%)	27(22%)	<0.05
Mechanical ventilation	110(29%)	52(42%)	<0.05
Time taken to reach the scene, minutes	15(10–20)	15(10–20)	NS
Time taken to reach the hospital, minutes	45(24–80)	45(25–77)	<0.05
ASA	1(1–2)	1(1–2)	<0.05
Hospital phase			
Systolic arterial pressure, mmHg	124 ± 29	119 ± 29	NS
Heart rate, beats/min	88 ± 23	93 ± 26	<0.05
Hemoglobin, g/dl	12.86 ± 2.11	11.93 ± 2.42	<0.05
Blood alcohol level, g/dl	0.23 ± 0.60	0.57 ± 0.95	<0.05
FAST results			NS
Negative	238(77%)	83(72%)	
Positive	70(23%)	32(28%)	
Open fracture	56 (15%)	28 (23%)	NS
Surgery or interventional direct	14(5%)	9(9%)	NS
Emergency procedure	149(38%)	77(61%)	<0.05
Neurosurgery	36 (9%)	17(13%)	NS
Orthopedic surgery	74(19%)	34 (27%)	NS
Thoracic surgery	7 (2%)	4 (3%)	NS
Visceral surgery	19(5%)	22(17%)	<0.05
Radiologic intervention	9 (2%)	11(9%)	<0.05
Vascular surgery	9(2%)	11(9%)	<0.05
Other surgery	5(1%)	4(3%)	NS
Massive hemorrhage	25 (6%)	29(23%)	<0.05
Cranial trauma	127 (32%)	51 (40%)	NS
Duration of stay in the ICU, days	3 (2–6)	5 (3–8)	<0.05
Duration of stay in the hospital, days	9(4–16)	11(5–22)	<0.05
Causes of death			<0.05
Brain death	7(19%)	12(50%)	
Cranial trauma	12(32%)	3(13%)	
Hemorrhagic shock	1(3%)	3(13%)	
Limitation of life sustaining treatment	7(19%)	2(8%)	
Multiple organ failure	7(19%)	2(8%)	
Other	3(8%)	2(8%)	
SAPS II	30(19–46)	40.5 (28.25–60.75)	<0.05
SOFA	2 (0–5)	5 (2–8)	<0.05
ISS	16(9–25)	18(9–26.5)	<0.05
RTS	7.84 (5.97–7.84)	6.38 (5–7.84)	<0.05
TRISS	0.03 (0.01–0.12)	0.05 (0.01–0.32)	<0.05
Death	37(61%)	24(39%)	<0.05

Table 4. Multivariate analysis: factors associated with mortality.

Variables	OR	95%CI	p
normalization of lactate	1,8	0,5–8,0	0.4
Sex (M)	0,2	0,03–1,1	0.07
GCS initial (>9)	0.8*	0.61–0.96	0.04
Cardiorespiratory arrest pre hospital	62*	2.2–4400	0.03
Systolic arterial blood pressure min	1,0	1,0–1,1	0.5
Diastolic arterial blood pressure min	1,0	0,9–1,1	0.8
Hemoglobin	0,8	0,5–1,1	0.1
Catecholamine	0,7	0,1–4,4	0.7
Mechanical ventilation	2,6	0,2–35	0.4
PH>7,37	0.0028*	0.00066–0.52	0.04
platelets	1,0	1,0–1,0	0.05
Fibrinogen >2 g/dL	0,4	0,1–0,9	0.06
Emergency procedure	0,1	0,05–3,0	0.2

Multivariate analysis with the different factors chosen in the analysis. *: independent association with mortality. OR: Odd Ratio. 95 CI: 95% confidence Interval

Table 5. Multivariate analysis: factors associated with normalization of lactate.

Variables	OR	95%CI	p
Sex (Males)	2.3*	1.1–4.6	0.02
Blood alcoholic level	0.6*	0.4–0.9	0.02
Systolic arterial blood pressure min	1,0	0,9–1,0	0.3
Diastolic arterial blood pressure min	1,0	0,9–1,0	0.3
Cardiorespiratory arrest pre hospital	1,0	0,2–6,2	1
Hemoglobin	1,0	0,9–1,2	1
Catecholamine	1,1	0,4–3,2	0.8
Mechanical ventilation	0,9	0,4–3,4	0.8
PH>7,37	1,0	0,8–135	0.09
platelets	1,0	0,9–1,0	0.4
Fibrinogen >2 g/dL	1,4	1,0–2,1	0.09
Emergency procedure	0,9	0,2–3,8	0.9

Multivariate analysis with the different factors chosen in the analysis. *: independent association with normalization of lactate in the 24 first hours. OR: Odd Ratio. 95 CI: 95% confidence Interval

the fact that GCS was included into gravity scores for trauma population (MGAP for instance) [23].

In the present study, pH was independently associated with hospital mortality. Indeed, an essential diagnostic for monitoring resuscitation and predicting the prognosis of trauma patients is arterial base excess [24,25]. Numerous publications have linked arterial base excess to persistent bleeding, the eventual onset of multiple organ failure, and hospital death [26,27]. Indeed, the so-called "lethal triad," which consists of coagulopathy, hypothermia, and acidosis, is the most well known of numerous important variables that have been linked to an increase in hospital mortality in trauma patients [28]. In fact, a previous study assessed the hospital death risk for trauma patients who arrive with a pH below 7.0. Hospital mortality was 3.0 times greater in the pH <7.0 cohort than in the pH ≥ 7.0 cohort in 2017, according to a retrospective assessment of 593 trauma patients by Samuel W. Ross et al. (62.1 vs. 20.3%; $p < 0.0001$) [29].

Regarding serum lactate clearance or non-normalization of serum lactate in the first 24 hours, our results showed that only the sex of patients (being a male) and alcohol intake were independently associated with serum lactate clearance. Alcohol or drug use, which are common circumstances, does not alter the prognostic power of initial serum lactate levels in trauma patients [30] . This could be explained by the fact that injury severity was significantly higher in patients with positive alcohol and drug screenings than in those with negative alcohol and drug screens. This correlates with our study which did not assess a worst prognosis in patient with alcohol use. Nonetheless, blood alcohol level was found to be a risk factor for non-normalization of serum lactate. This might be supported by the altered NADH/NAD+ ratio, which causes greater lactate production and resulting base deficit. As a result, the threshold for aberrant readings to indicate altered perfusion and reduced oxygen delivery is higher than that observed in patients who test negative for ethanol [30].

As for being a male or a female, no studies reported that lactate metabolism was different depending on the sex of patients. In our study, being a woman meant being at risk of not normalizing serum lactate in the first 24 hours of care. Female trauma patients represent a minority of trauma population (20% in our study). Non-normalization of serum lactate or being a female was not found to be factors associated with hospital mortality. Thus, it could be that serum lactate clearance is different in men and women after trauma, but to date, no studies support this fact.

Our study has several limitations. First, there are numerous missing data. Thus, we presumed that serum lactate levels stayed normal if it was normal at arrival and that the patient's length of stay was short. Nevertheless, this extrapolation could be wrong. Moreover, we did not include patients with hepatic trauma. However, the possible effect of hepatic contusion on serum lactate levels is unknown. Initial blood lactate levels were considerably higher in hepatic trauma patients, according to Reigner and colleagues, but this difference disappeared after the global severity (TRISS) was corrected for. This finding indicates that serum lactate clearance pathways in trauma patients may be altered, indicating that hepatic trauma does not have a substantial impact [15].

7. Conclusion

Although serum lactate at admission is associated with trauma patient prognosis, our study failed to show that non-normalization of serum lactate in the initial 24 hours was a factor that could predict hospital mortality. A future study focusing on normalizing serum lactate in a shorter scale of time could be interesting.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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