



OPEN Bland–Altman plot to assess the consistency of arterial and venous blood lactate in the emergency room: a retrospective cohort study

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To measure the correlation and agreement between arterial and peripheral venous blood lactate in the emergency room and to assess the predictive value of lactate for the occurrence of cardiac arrest. This was a retrospective cohort study involving 784 patients from January 1, 2020, to July 31, 2021, in the Emergency Room of the First Affiliated Hospital of Xinjiang Medical University. General information, vital signs, clinical symptoms, and laboratory findings of the patient were collected. Linear regression was used to analyze the correlation between arterial and venous blood lactate, Bland–Altman plots were drawn to assess the concordance of (arterial-venous) serum lactate concentrations, and the predictive value of arterial and venous lactate for the occurrence of cardiac arrest was assessed by using the receiver operating characteristic curve (ROC). A total of 784 emergency room patients were included in the study, of whom 384 experienced cardiac arrest and 400 had no cardiac arrest. Arterial and venous lactate univariate linear regression analysis, correlation coefficient $r = 0.80$, linear equation $Y_{(\text{venous blood lactate})} = 0.729 + 0.960 \times X_{(\text{arterial blood lactate})}$ and had statistical significance ($P < 0.001$); arterial blood (lactate) and venous blood (lactate) were -0.548 (95%CI $-0.774 \sim -0.322$ mmol/L), and the upper and lower limits of the 95% limits of agreement (LoA) were 5.777 (95%CI $5.390 \sim 6.163$ mmol/L) and -6.872 ($-7.2590 \sim -6.4855$ mmol/L), indicating that the consistency of arterial blood lactate and venous blood lactate is poor and statistically significant ($P < 0.001$). The results of this study show that venous and arterial blood lactate levels are not identical, but are highly correlated and are important predictors of cardiac arrest in emergency room patients.

Keywords Arterial blood lactate, Venous blood lactate, Cardiac arrest, Bland–Altman plot

Because of insufficient oxygen supply to the body lactate serves as a product of a metabolic pathway (glycolysis) and as a substrate for a pathway downstream of the product (mitochondria)^{1,2}. The importance of lactate levels for diagnosis, prognosis, risk stratification, and therapeutic guidance is well established^{3,4}. In past cohort studies, the correlation between arterial and venous blood lactate was high^{5,6}. Lactate plays an important role in the early detection of sepsis, and organ dysfunction is critical in critically ill patients to initiate and monitor appropriate therapeutic measures⁷. Compared to venous sampling, arterial sampling is the gold standard for measuring lactate levels in the emergency room or intensive care unit and is a favorable tool for evaluating sepsis, respiratory failure, metabolic diseases, etc. However, arterial puncture is technically more demanding than venous puncture during its operation, requires specialized knowledge, and may be associated with serious complications, especially in hypotensive patients. Intravenous blood collection is technically less demanding, safer, and less painful, and allows for blood to be drawn at the same time as the intravenous indwelling line procedure, which is routinely performed on all patients. This study sought to measure the correlation and concordance between arterial and peripheral venous blood lactate with the aim of testing the interchangeability of the two and supporting the assessment of the predictive value of lactate for the occurrence of cardiac arrest in emergency room patients.

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Information and methods

Study subjects

This study retrospectively included patients who visited the Emergency Department of the First Affiliated Hospital of Xinjiang Medical University and were admitted to the emergency room from January 1, 2020, to July 31, 2021, and suffered cardiac arrest within 24 h.

Inclusion criteria

(1) Age ≥ 18 years; (2) meeting the diagnostic criteria for cardiac arrest in the guidelines for cardiopulmonary resuscitation⁸; all patients who developed cardiac arrest in the emergency room.

Exclusion criteria

(1) Patients had cardiac arrest before admission; (2) cardiac arrest occurred outside the hospital; (3) patients with malignant tumors or other diseases in the terminal stage; (4) patients with traumatic injuries (life-threatening); (5) patients with missing clinical data.

Ethics

This study complied with the standards of medical ethics, and the current study followed the principles of the Declaration of Helsinki⁹, which was approved by the Medical Ethics Committee of the First Affiliated Hospital of Xinjiang Medical University (Approval No. K202301-27) without the need for written informed consent.

Data collection

Retrieve patient case information through the hospital's outpatient medical record system. The information included the patient's general condition (gender, age); race (Han, Uyghur, Kazakh, other); Modified Early Warning Score (Mews) on admission to the emergency room (scored as < 5 , ≥ 5); vital signs [temperature, heart rate, systolic blood pressure (SBP), mean arterial pressure (MAP), respiratory rate]; the presence of endotracheal intubation; state of consciousness (alert, reactive to voice, reactive to pain, unresponsive); symptoms (hemoptysis, chest distress, dyspnea, etc.); and medical history (hypertension, diabetes, cardiac disease, and renal disease); Blood routine examinations include white blood cell (WBC), neutrophil count (NEU), lymphocyte count (LYM), red blood cell count (RBC), red blood cell pressure (HCT), hemoglobin (HB), platelet count (PLT); Biochemical parameters include urea (BUN), creatinine (Cre), glucose (GLU), lactate (venous blood) normal range: 0.7 ~ 2.1 mmol/L, total cholesterol (CHO), low-density lipoprotein (LDL), direct bilirubin (DBI), indirect bilirubin (IBIL), albumin (ALB), globulin (GLO), albumin/globulin ratio (A/G), aspartate aminotransferase (AST), alanine aminotransferase (ALT), osmolality (OSM); Blood gas analysis indicators include pH, partial pressure of carbon dioxide (PCO_2), partial pressure of oxygen (PaO_2), sodium ion (Na^+), potassium ion (K^+), calcium ion (Ca^{2+}), bicarbonate ion (HCO^-), LAC (Lactate in arterial blood) Normal range: 0.5 ~ 1.6 mmol/L, lactate/albumin ratio (L/A); Coagulation indices include prothrombin time (PT), prothrombin time activity (PTA), international normalized ratio (INR), fibrinogen (FIB), activated partial thromboplastin time (APTT), prothrombin time (TT), and D-dimer (D-dimer); Inflammatory factors include C-reactive protein (CRP), interleukin-6 (IL-6), and procalcitonin (PCT); Cardiac markers include troponin I (cTnI), creatine kinase isoenzyme (CK-MB), and B-type natriuretic peptide (BNP). All of the above tests were performed within 24 h of the patient's emergency room visit. After the patient entered the emergency room, arterial blood gas was collected by radial artery puncture, and arterial and venous blood were collected within 5 min. Tourniquet retention time is less than 1 min. Biochemistry indicators using VITROS® 5600 automatic biochemistry and immune analyzer, from Osendo medical equipment Trading (China) Co. Arterial blood gas analysis index using Instrumentation Laboratory GEM Premier 3500 blood gas analysis equipment, from Instrumentation Laboratory (IL). This study attempts to measure the correlation and agreement between arterial and peripheral venous blood lactate in the emergency room and to assess the predictive value of lactate for the occurrence of cardiac arrest.

Quality control

Three researchers (LYK, LDD, and YX) collected data for this study. During the data collection process, any disagreements were resolved through consultation with the corresponding authors (YJZ and XJ) before deciding whether to include them in the study. The researchers (LYK and HXJ) collated and analyzed the data, and the author (LYK) wrote the article based on the reporting items recommended by the Bland–Altman consistency assessment¹⁰, and the corresponding authors (YJZ and XJ) supervised the writing quality of the article.

Statistical methods

SPSS (IBM SPSS Statistics 26.0, SPSS Inc., Chicago, IL), MedCalc (version 20.0, MedCalc Software Ltd), and GraphPad Prism (version 9.0, GraphPad Software) software were used for statistical analysis and data visualization. The measures in this study were non-normally distributed, expressed as medians (IQR), and the Mann–Whitney *U* test was used for between-group comparisons. For categorical variables, expressed as frequencies and percentages, between-group comparisons were made using the chi-square test or Fisher's exact test. Pearson correlation coefficients were used for the relationship between venous and arterial lactate levels. The receiver operator characteristic curve (ROC) was plotted and the area under the ROC curve (AUC) was calculated. Bland–Altman plots were drawn to assess the concordance of (arterial-venous) serum lactate concentrations. Differences were considered statistically significant at $P < 0.05$.

In our study, with an alpha level (α) set at 0.05 and aiming for a statistical power of 80% ($1 - \beta = 0.8$). The sample size was calculated on the basis of a preliminary analysis of 193 patients. We used PASS software (version 20.0.6) to calculate the required sample size.

Results

Study population

The flow diagram is illustrated in Fig. 1.

General information

In this study, from January 1, 2020, to July 31, 2021, a total of 143,440 patients were seen in the emergency department, 19,691 patients were admitted to the emergency room for treatment, and 401 (2.04%) patients suffered from cardiac arrest, and according to the inclusion and exclusion criteria 784 emergency room patients were finally included, and 400 patients did not suffer from cardiac arrest, with the average age of 63 (50–77) years old, 232 (46.8%) males and 168 (58.3%) females; 384 patients of cardiac arrest occurred, with the average age of 62 (49–76) years old, 264 (53.2%) males and 120 (41.7%) females. There was no significant difference in race between the Cardiac arrest group and the no cardiac arrest group. Arterial blood (lactate) was 1.5 (1.10–2.20) mmol/L in the absence of cardiac arrest and 6.4 (3.00–11.08) mmol/L in the occurrence of cardiac arrest, and the difference was statistically significant ($P < 0.001$); venous blood (lactate) was 1.81 (1.33–2.57) mmol/L in the absence of cardiac arrest and 6.63 (3.22–11.38) mmol/L in the occurrence of cardiac arrest, and the difference was statistically significant ($P < 0.001$) (Table 1).

Linear correlation analysis

Arterial blood (lactate) and venous blood (lactate) were analyzed by Pearson's correlation analysis, which showed that the correlation coefficient $r = 0.80$, and the linear equation Y (venous blood lactate) $= 0.729 + 0.960 * X$ (arterial blood lactate), and was statistically significant ($P < 0.001$), and the linear correlation and the heat map were plotted (Fig. 2).

The normal range of lactate (venous blood) in laboratory tests was 0.7 to 2.1 mmol/L. This was used as a cutoff value and converted to a categorical variable, with values of lactate (venous blood) < 0.7 mmol/L, 0.7 to 2.1 mmol/L, and > 2.1 mmol/L noted as 1, 2, and 3. The normal range of LAC (arterial blood) was 0.5–1.6 mmol/L, which was used as the cut-off value and converted into a categorical variable, and the values of

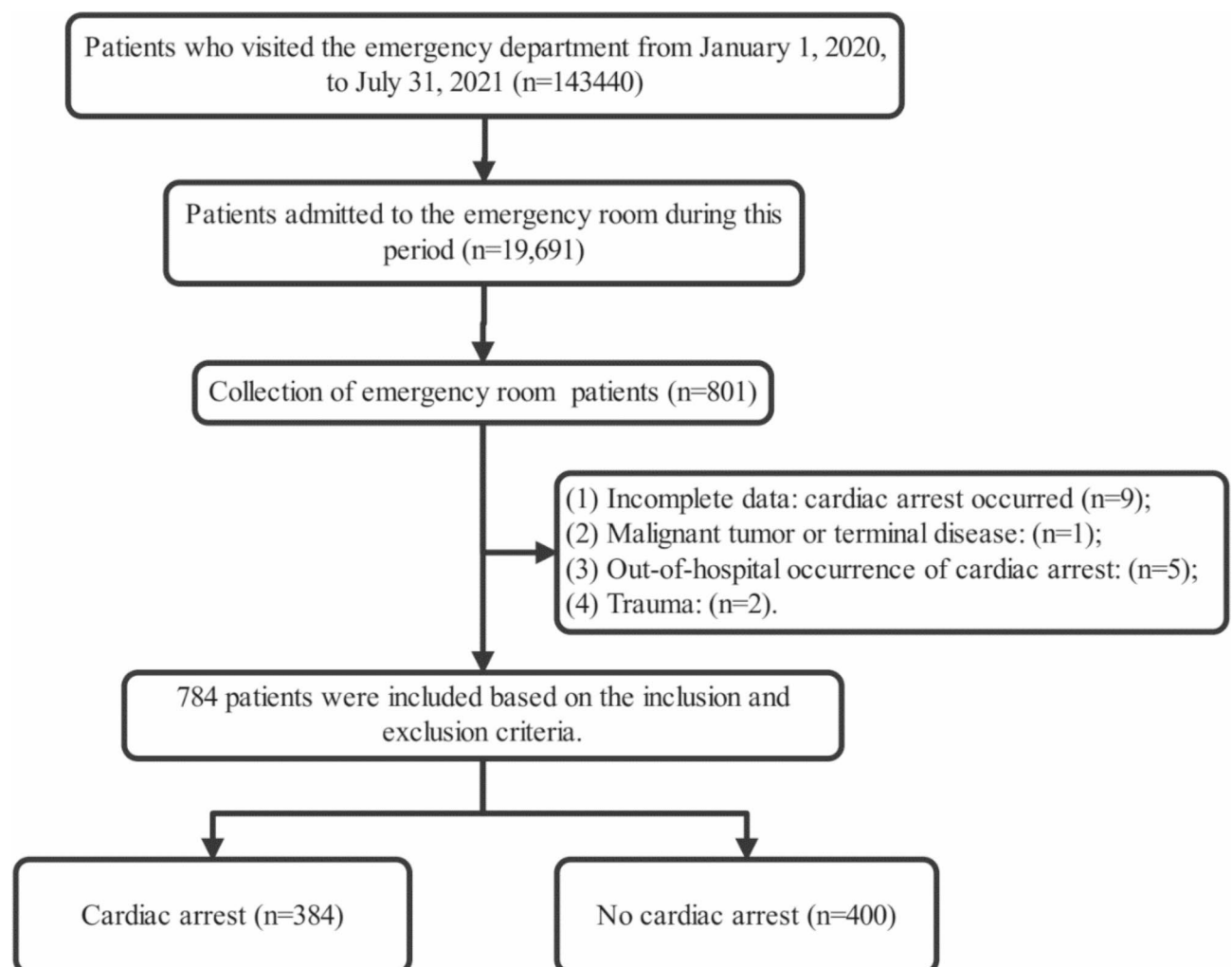


Fig. 1. Study flow diagram.

Characteristic		No cardiac arrest (<i>n</i> = 400)	Cardiac arrest (<i>n</i> = 384)	Z/ χ^2	<i>P</i>
Gender (<i>n</i> (%)) [§]	Male [#]	232 (46.8)	264 (53.2)	9.742	0.002
	Female [#]	168 (58.3)	120 (41.7)		
Age (years)		63 (50 ~ 77)	62 (49 ~ 76)	-1.003	0.316
Race (<i>n</i> (%))					
Han [#]		302 (50.8)	292 (49.2)	0.041	0.998
Uyghur [#]		54 (51.4)	51 (48.6)		
Kazakh [#]		10 (52.6)	9 (47.4)		
Other [#]		34 (51.5)	32 (48.5)		
Mews score (<i>n</i> (%)) [§]					
< 5 [#]		378 (63.2)	220 (36.8)	1419.890	< 0.001
≥ 5 [#]		22 (11.8)	164 (88.2)		
Vital signs					
Temperature (°C)* [§]		36.5 (36.30 ~ 36.88)	36.7 (36.30 ~ 36.90)	-3.471	0.001
Heart rate (beats/min)* [§]		88 (75 ~ 105)	102 (88 ~ 117)	-6.719	< 0.001
SBP (mmHg)* [§]		137.5 (117 ~ 159)	121 (100.00 ~ 132.75)	-8.901	< 0.001
MAP (mmHg)* [§]		97 (86 ~ 112)	88 (74 ~ 96)	-8.118	< 0.001
Respiratory rate (次/分)* [§]		20 (16 ~ 20)	20 (18 ~ 21)	-3.776	< 0.001
Tracheal intubation* [§]	No	392 (81.7)	88 (18.3)	465.243	< 0.001
	Yes	8 (2.6)	296 (97.4)		
State of consciousness (<i>n</i> (%)) [§]					
Alert [#]		380 (62.8)	225 (37.2)	149.871	< 0.001
Reacts to voice [#]		5 (20.8)	19 (79.2)		
Reacts to pain [#]		6 (19.4)	25 (80.6)		
Unresponsive [#]		9 (7.3)	115 (92.7)		
Symptoms (<i>n</i> (%))					
Hemoptysis* [§]	No	386 (50.5)	379 (49.5)	4.002	0.045
	Yes	14 (73.7)	5 (26.3)		
Chest distress* [§]	No	265 (48.0)	287 (52.0)	6.777	0.009
	Yes	135 (58.2)	97 (41.8)		
Dyspnea* [§]	No	349 (53.2)	307 (46.8)	7.647	0.006
	Yes	51 (39.8)	77 (60.2)		
Palpitation [#]	No	369 (51.9)	342 (48.1)	2.357	0.125
	Yes	31 (42.5)	42 (57.5)		
Chest pain [#]	No	326 (51.4)	308 (48.6)	0.211	0.646
	Yes	74 (49.3)	76 (50.7)		
Abdominal Pain* [§]	No	385 (53.5)	335 (46.5)	21.217	< 0.001
	Yes	15 (23.4)	49 (76.6)		
Diarrhea [#]	No	391 (51.0)	376 (49.0)	0.026	0.873
	Yes	9 (52.9)	8 (47.1)		
Haematemesis* [§]	No	392 (52.2)	359 (47.8)	9.885	0.002
	Yes	8 (24.2)	25 (75.8)		
Hematochezia [#]	No	381 (51.5)	359 (48.5)	1.146	0.284
	Yes	19 (43.2)	25 (56.8)		
Vomiting* [§]	No	346 (53.0)	307 (47.0)	6.043	0.014
	Yes	54 (41.2)	77 (58.8)		
Oliguria [#]	No	382 (51.2)	364 (48.8)	0.213	0.644
	Yes	18 (47.4)	20 (52.6)		
Polyuria [#]	No	399 (51.0)	384 (49.0)	-	1.000
	Yes	1 (100)	0 (0)		
Hematuria [#]	No	399 (51.2)	380 (48.8)	0.890	0.346
	Yes	1 (20)	4 (80)		
Seizure [#]	No	394 (51.0)	378 (49.0)	0.005	0.943
	Yes	6 (50)	6 (50)		
Cold extremities* [§]	No	392 (56.2)	306 (43.8)	67.274	< 0.001
	Yes	8 (9.3)	78 (90.7)		
Medical history (<i>n</i> (%))					
Continued					

Characteristic		No cardiac arrest (<i>n</i> = 400)	Cardiac arrest (<i>n</i> = 384)	Z/ χ^2	<i>P</i>
Hypertension [#]	No	202 (48.7)	213 (51.3)	1.941	0.164
	Yes	198 (53.7)	171 (46.3)		
Diabetes [#]	No	296 (49.2)	306 (50.8)	3.555	0.059
	Yes	104 (57.1)	78 (42.9)		
Cardiac disease [#]	No	302 (50.7)	294 (49.3)	0.121	0.778
	Yes	98 (52.1)	90 (47.9)		
Renal disease [#]	No	384 (50.7)	374 (49.3)	1.191	0.275
	Yes	16 (61.5)	10 (38.5)		
Blood routine examinations					
WBC (10 ⁹ /L)* [§]		7.60 (5.65 ~ 9.98)	13.08 (9.05 ~ 18.25)	-12.901	<0.001
NEU (10 ⁹ /L)* [§]		5.31 (3.71 ~ 7.51)	9.86 (5.77 ~ 15.27)	-10.734	<0.001
LYM (10 ⁹ /L)* [§]		1.22 (0.78 ~ 1.72)	1.51 (0.84 ~ 3.39)	-5.047	<0.001
RBC (10 ¹² /L)* [§]		4.30 (3.57 ~ 4.81)	3.94 (2.82 ~ 4.77)	-3.860	<0.001
HCT* [§]		38.4 (32.00 ~ 42.80)	36.8 (26.20 ~ 43.40)	-2.512	0.012
HGB (g/L)* [§]		129 (106.25 ~ 145.00)	118 (88 ~ 144)	-3.948	<0.001
PLT (10 ⁹ /L)* [§]		192.5 (138.00 ~ 247.75)	162.5 (98.50 ~ 243.00)	-3.781	<0.001
Biochemical parameters					
BUN (mmol/L)* [§]		6.25 (4.52 ~ 8.91)	8.57 (5.95 ~ 15.09)	-7.535	<0.001
Cre (umol/L)* [§]		68.34 (52.22 ~ 95.58)	105.57 (70.89 ~ 196.15)	-9.091	<0.001
GLU (mmol/L)* [§]		7.48 (6.15 ~ 9.81)	9.66 (6.59 ~ 14.74)	-5.699	<0.001
Lactate (mmol/L)* [§]		1.81 (1.33 ~ 2.57)	6.63 (3.22 ~ 11.38)	-17.599	<0.001
CHO (mmol/L)* [§]		3.8 (3.00 ~ 4.63)	3.16 (2.16 ~ 4.04)	-7.409	<0.001
LDL (mmol/L) [§]		2.18 (1.60 ~ 2.87)	1.68 (1.03 ~ 2.47)	-6.541	<0.001
DBI (umol/L)* [§]		0.3 (0.3 ~ 0.3)	0.3 (0.3 ~ 0.3)	-6.283	<0.001
IBIL (umol/L)*		9.30 (5.69 ~ 14.81)	9.46 (5.49 ~ 16.56)	-0.833	0.405
ALB (g/L)* [§]		38.80 (34 ~ 43)	34.96 (27.99 ~ 39.50)	-7.761	<0.001
GLO (g/L)* [§]		32.65 (29.47 ~ 36.55)	31.08 (26.55 ~ 35.19)	-4.473	<0.001
A/G* [§]		1.16 (1.00 ~ 1.33)	1.08 (0.89 ~ 1.29)	-3.946	<0.001
AST (U/L)* [§]		30.06 (23.36 ~ 44.30)	72.11 (34.93 ~ 220.44)	-12.443	<0.001
ALT (U/L)* [§]		26.85 (18.46 ~ 45)	44.49 (21.51 ~ 125.27)	-6.694	<0.001
OSM (mOSM/L)* [§]		270.48 (264.56 ~ 276.23)	279.07 (269.78 ~ 286.82)	-8.792	<0.001
Blood gas					
pH*		7.43 (7.40 ~ 7.46)	7.235 (7.08 ~ 7.41)	-14.000	<0.001
PCO ₂ (mmHg)* [§]		32 (28 ~ 37)	34 (25 ~ 48)	-2.446	0.014
PaO ₂ (mmHg)* [§]		102.5 (81 ~ 132)	85.5 (60 ~ 119)	-6.350	<0.001
Na ⁺ (mmol/L)* [§]		134 (131 ~ 136)	135 (130 ~ 139)	-1.957	<0.001
K ⁺ (mmol/L)* [§]		3.8 (3.50 ~ 4.18)	4.6 (3.80 ~ 5.28)	-10.157	<0.001
Ca ²⁺ (mmol/L)* [§]		1.1 (1.05 ~ 1.14)	1.05 (0.99 ~ 1.12)	-6.492	<0.001
HCO ⁻ (mmol/L)* [§]		21.42 (19 ~ 24)	16.21 (12.33 ~ 19.60)	-13.211	<0.001
LAC (mmol/L)* [§]		1.5 (1.10 ~ 2.20)	6.4 (3.00 ~ 11.08)	-18.246	<0.001
L/A* [§]		0.04 (0.03 ~ 0.06)	0.18 (0.09 ~ 0.35)	-18.698	<0.001
Coagulation indices					
PT (s)* [§]		12.4 (11.5 ~ 14)	14.8 (12.7 ~ 18.3)	-9.967	<0.001
PTA (%)* [§]		82.21 (62.50 ~ 97.85)	61.65 (41.07 ~ 79.31)	-9.004	<0.001
INR* [§]		1.10 (1.02 ~ 1.25)	1.3 (1.1 ~ 1.63)	-8.358	<0.001
FIB(g/L)* [§]		3.49 (2.88 ~ 3.95)	3.23 (2.17 ~ 3.93)	-4.264	<0.001
APTT (s)* [§]		31.3 (28.7 ~ 33.9)	33.7 (29.1 ~ 38.8)	-5.549	<0.001
TT (s)* [§]		19.8 (18.5 ~ 21.58)	21.3 (19.1 ~ 23.9)	-6.199	<0.001
D-dimer (ng/ml)* [§]		296.5 (117.5 ~ 876.5)	2711 (863 ~ 8420)	-16.157	<0.001
Inflammatory factors					
CRP (mg/L)* [§]		13.15 (5.93 ~ 33.90)	42.25 (9.75 ~ 82.50)	-7.340	<0.001
IL-6 (pg/ml)* [§]		11.33 (5.02 ~ 39.25)	217.7 (56.24 ~ 972.78)	-17.835	<0.001
PCT (ng/ml)* [§]		0.07 (0.04 ~ 0.21)	0.51 (0.10 ~ 9.41)	-10.993	<0.001
Cardiac markers					
cTnI (ng/L)* [§]		0.014 (0.012 ~ 0.044)	0.136 (0.020 ~ 1.500)	-10.909	<0.001
Continued					

Characteristic	No cardiac arrest (n = 400)	Cardiac arrest (n = 384)	Z/x ²	P
CK-MB (U/L)* [§]	1.09 (0.65 ~ 2.09)	3.65 (1.27 ~ 15.22)	-10.756	< 0.001
BNP (ng/L)* [§]	400.5 (78.33 ~ 2062.50)	3010 (459.25 ~ 7236.00)	-9.890	< 0.001

Table 1. General information on patients without cardiac arrest and those with cardiac arrest in the emergency room. *Represented as a non-normally distributed continuous variable, expressed as the median of the interquartile range, and analyzed by the nonparametric Mann–Whitney *U* test. #Indicates that categorical variables were expressed as frequencies and percentages and analyzed by the chi-square test or Fisher's exact test. §Indicates that the difference was statistically significant in the comparison between those who had a cardiac arrest and those who did not ($P < 0.05$). MAP is mean arterial pressure; WBC is white blood cell; NEU is neutrophil count; LYM is lymphocyte count; RBC is red blood cell count; HCT is erythrocyte pressure volume; HB is hemoglobin; PLT is platelet count; BUN is urea; Cre is creatinine; GLU is glucose; Lactate is venous Lactate; CHO is total cholesterol; LDL is low-density lipoprotein; DBI is direct bilirubin; IBIL is indirect bilirubin; ALB is albumin; GLO is globulin; A/G is albumin/globulin ratio; AST is aspartate aminotransferase; ALT is alanine aminotransferase; OSM is osmolality; pH, PCO₂ is partial pressure of carbon dioxide; PaO₂ is partial pressure of oxygen in arterial blood; Na⁺ is sodium; K⁺ is potassium; Ca²⁺ is calcium; HCO⁻ is carbonic acid Na⁺ for sodium ions; K⁺ for potassium ions; Ca²⁺ for calcium ions; HCO⁻ for bicarbonate ions; LAC for arterial blood lactate, L/A for lactate/albumin ratio; PT for prothrombin time; PTA for prothrombin time activity; INR for International Normalized Ratio; FIB for fibrinogen; APTT for Activated Partial Thromboplastin Time; TT for Thromboplastin Time; D-dimer for D-dimer; CRP is C-reactive protein; IL-6 is interleukin-6; PCT is procalcitonin; cTnI is troponin I; CK-MB is creatine kinase isoenzyme; BNP is B-type natriuretic peptide.

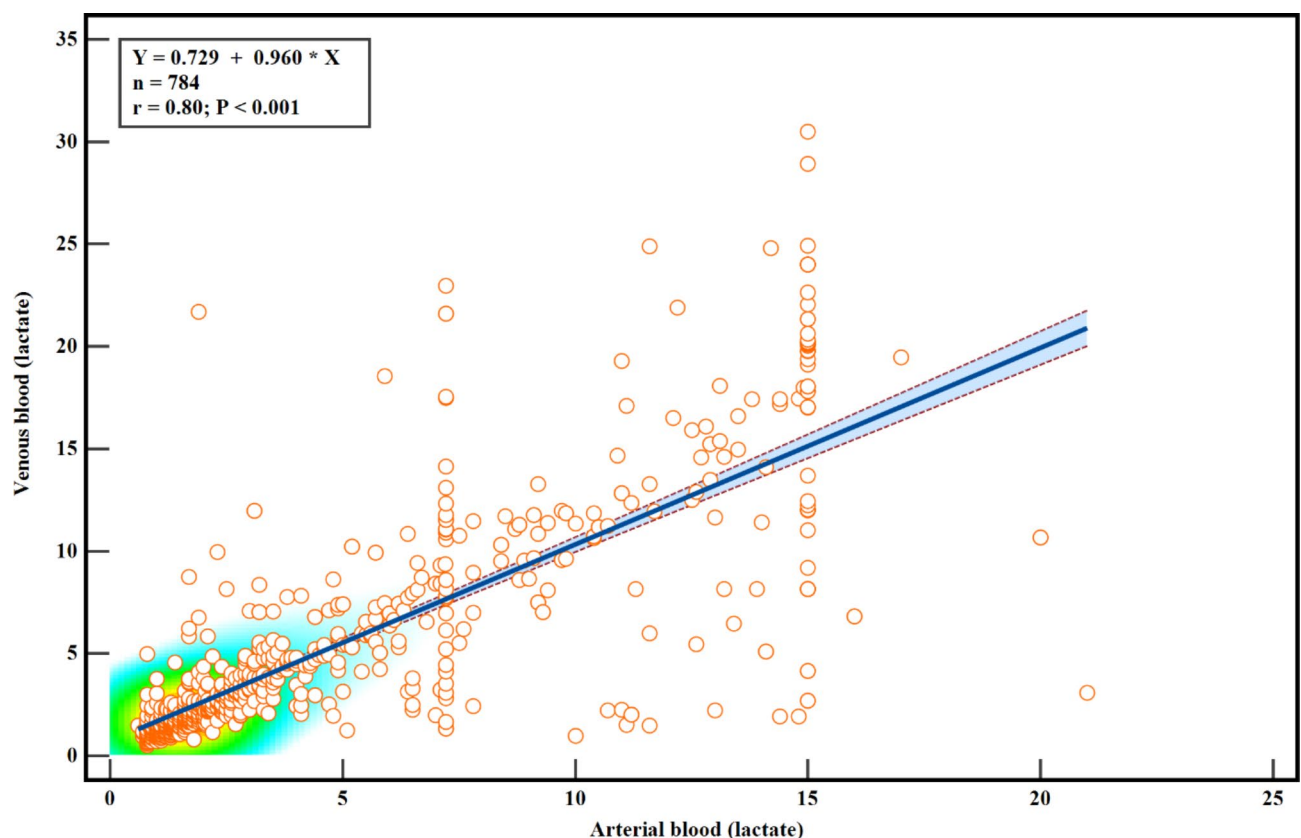


Fig. 2. Linear correlation plot between arterial blood (lactate) and venous blood (lactate).

LAC (arterial blood) < 0.5 mmol/L, 0.5 ~ 1.6 mmol/L, and > 1.6 mmol/L were recorded as 1, 2, and 3. The Kappa coefficient value of the Kappa consistency test result was 0.713 ($P < 0.001$), between 0.6 and 0.8, with a strong level of consistency, suggesting that VITROS * 5600 automatic biochemistry and immunoassay analyzer and Instrumentation Laboratory GEM Premier 3500 blood gas analyzer have a strong match for the blood lactate level.

The mean difference between arterial blood (lactate) and venous blood (lactate) at the time of admission to the emergency room was -0.548 (95% CI $-0.774 \sim -0.322$ mmol/L). The upper and lower 95% limits of agreement (LoA) were 5.777 (95% CI $5.390 \sim 6.163$ mmol/L) and -6.872 ($-7.2590 \sim -6.4855$ mmol/L), indicating poor and statistically significant agreement between arterial and venous blood lactate ($P < 0.001$) (Fig. 3).

ROC curve analysis of arterial and venous blood lactate indices predicting the occurrence of cardiac arrest in emergency room patients

Of the 784 emergency room patients, 384 had cardiac arrest. Among the indicators for predicting cardiac arrest, the AUC of arterial blood (lactate) in evaluating the prognosis of cardiac arrest was 0.876 (95% CI $0.851 \sim 0.899$), the best diagnostic cut-off value is > 2.8 mmol/L, the risk of cardiac arrest will increase if the cut-off value is higher than this cut-off value, the sensitivity is 77.08% , and the specificity is 85.50% . The AUC of venous blood (lactate) in assessing the prognosis for the occurrence of cardiac arrest was 0.863 (95% CI $0.837 \sim 0.886$), with an optimal diagnostic cut-off value of > 3.2 mmol/L, above which the risk of cardiac arrest would be increased, with a sensitivity of 75.52% and a specificity of 85.25% . The result shows that statistically significant in predicting the occurrence of cardiac arrest ROC curves were performed with the area under the curves of 0.876 and 0.863 . The comparison of AUC between arterial (lactate) and venous (lactate) blood showed only a difference in the area of 0.013 and the difference was not statistically significant ($P = 0.128$) (Table 2, Supplementary Fig. 1). This indicates that arterial and venous blood lactate levels have the same predictive value for the occurrence of cardiac arrest in emergency room patients, with no significant difference.

Discussion

Arterial blood analysis has an important role in the clinical assessment of critically ill patients. In particular, arterial lactate can provide valuable information about peripheral circulatory failure, usually due to hypovolemia or systemic hypoxia^{11,12}. In emergency or intensive care units, the radial artery is often used for arterial blood gas sampling, and when the radial artery cannot be punctured because of hypotension or inadequate tissue perfusion, other arteries, such as the femoral artery, are used, and the adverse consequences of arterial punctures, such as pain, intimal tear, hematoma, pseudoaneurysm, arteriovenous fistulae, and retroperitoneal hemorrhage, are often a cause for concern, whereas venous blood sampling is usually easier, less painful, and more convenient¹³.

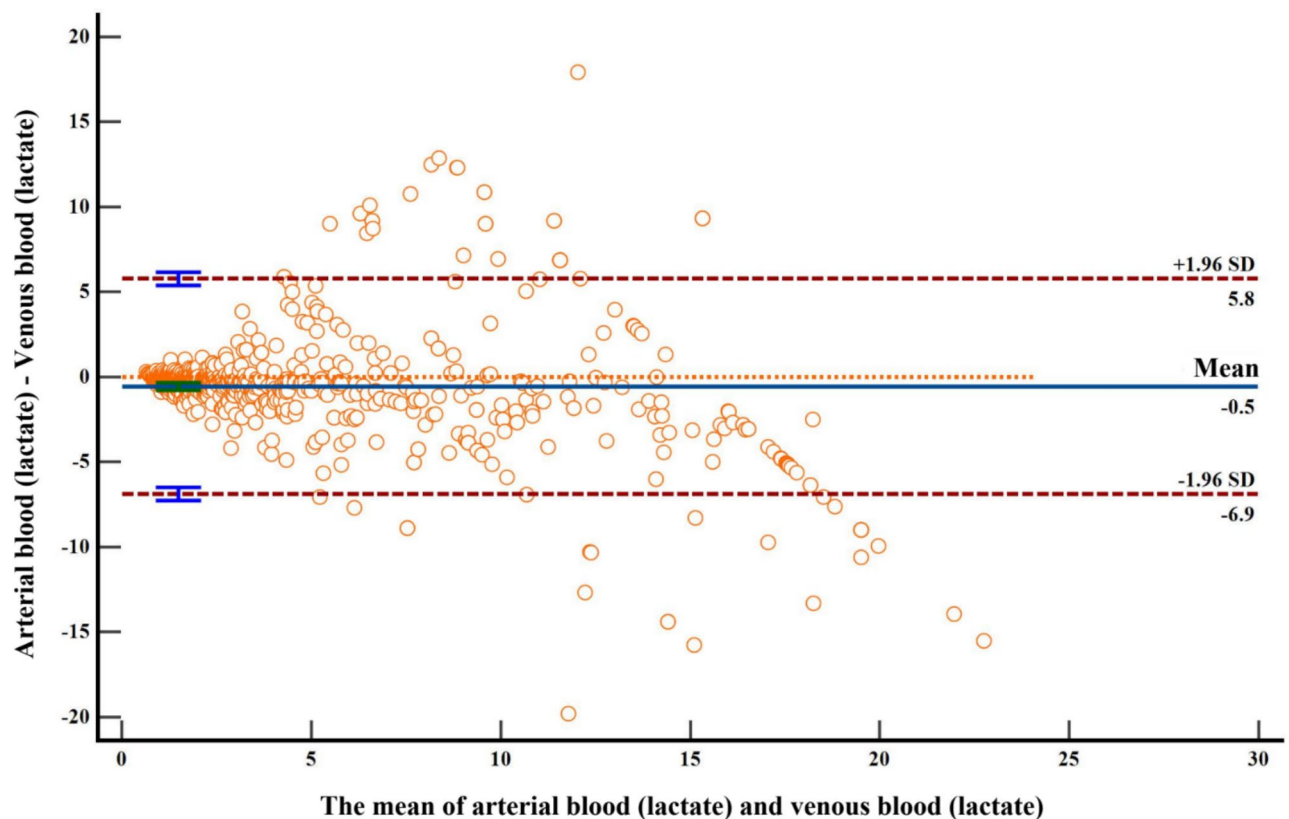


Fig. 3. Bland–Altman plots comparing arterial and venous concentrations of lactate; the bias and precision of the comparisons are depicted on the plots. The two red horizontal dashed lines at the top and bottom of the plot indicate the upper and lower limits of the 95% consistency limits, the blue horizontal solid line in the center represents the mean of the difference, and the orange horizontal dashed line indicates the location where the mean of the difference is 0.

Characteristic	AUC	Cut-off	Youden index	Sensitivity%	Specificity%	P	95%CI
Arterial blood lactate (mmol/L)	0.876	> 2.8	0.6528	77.08	85.50	< 0.001	0.851 ~ 0.899
Venous blood lactate (mmol/L)	0.863	> 3.2	0.6077	75.52	85.25	< 0.001	0.837 ~ 0.886

Table 2. Results of ROC curves of arterial and venous blood lactate indices predicting the occurrence of cardiac arrest in patients in the emergency room. AUC was the area under the receiver operator characteristic curve; the Cut-off value is the best.

A high correlation between arterial and peripheral venous blood lactate has been noted in previous sepsis studies, and peripheral venous blood lactate levels can be used as an indicator of assessment in the early stages of the development of septic shock^{14,15}. In a study of arterial and venous blood lactate and electrolytes², it was noted that when arterial blood lactate was > 4 mmol/L, a venous blood index could be used in place of arterial blood, and it was noted that the difference between the presence of arterial and venous blood lactate was not consistent when comparing the overall population, but showed consistency for the sepsis group. The study was not performed to describe whether the included conditions included patients with severe trauma, out-of-hospital cardiopulmonary resuscitation, whether the malignant quality of the disease had an impact on the results, and was not analyzed using the consistent Bland–Altman method, leaving the conclusions drawn open to question. In a meta-analysis evaluating the use of venous blood lactate in the emergency department, the results of a pooled literature analysis showed poor agreement between arterial and venous blood lactate and did not recommend the substitution of venous blood lactate for arterial blood lactate¹⁶. In a multicenter randomized controlled study, the critical lactate level for poor prognosis was shown to be ≥ 3 mmol/L¹⁷ or 4 mmol/L^{18,19}. In this study the optimal diagnostic cut-off values were > 2.8 mmol/L for arterial blood (lactate) and > 3.2 mmol/L for venous blood (lactate), which are close to and in line with the findings of previous studies. In the study by Nikola Schütz et al.²⁰, it was pointed out that pH value, bicarbonate ion, base residual value, and lactate in venous blood can be used as surrogates for arterial measurements. Confounding factors interfere with the results, and the research results will be biased. Large sample sizes should be used to avoid confounding factors and ensure the rigor of the research. In this study, the sample size reached 784 cases, and the mean difference between arterial and venous blood lactate analyzed according to the Bland–Altman plot was -0.548 (95% CI -0.774 ~ -0.322 mmol/L). The upper and lower limits of agreement (LoA) were 5.777 (95% CI 5.390 ~ 6.163 mmol/L) and -6.872 (-7.2590 ~ -6.4855 mmol/L), indicating that arterial and venous blood lactate were not significantly different from each other, which meant that the upper and lower limits were not significantly different from each other. 5.390 ~ 6.163 mmol/L and -6.872 (-7.2590 ~ -6.4855 mmol/L), indicating poor and statistically significant agreement between arterial and venous blood lactate ($P < 0.001$).

In the present study, arterial and venous blood lactate of emergency room patients were analyzed and the results showed statistically significant in predicting the occurrence of cardiac arrest ROC curves were performed with the area under the curves of 0.876 and 0.863, with sensitivity of 77.08% and 75.52%, and specificity of 85.50% and 85.25%, respectively. Both had similar predictive values in predicting the occurrence of cardiac arrest in patients in the emergency resuscitation room, and the difference was not statistically significant ($P = 0.128$).

Limitations of the study

(1) This study is a single-center retrospective study, and a multicenter prospective study can be carried out at a later stage for research. (2) Due to the complexity of the emergency department to incorporate patients' disease differences, the patient's condition changes rapidly, as far as possible to control its confounding factors to ensure the accuracy of the study.

Conclusions

In this study, we analyzed the relationship between venous and arterial blood lactate levels in emergency resuscitation room patients and determined whether venous blood lactate could be a substitute for arterial blood lactate levels. Our results showed that venous and arterial blood lactate levels were not identical but were highly correlated and were significant predictors of cardiac arrest in emergency room patients.

Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Received: 20 August 2024; Accepted: 1 January 2025

Published online: 16 January 2025

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Author contributions

Yongkai Li: research design, data collection, and organization, statistical analysis, thesis writing; Xiaojing He: data organization and statistical analysis; Dandan Li and Xin Yuan: data collection; Jun Xu: research design, thesis supervision, revision and review; Jianzhong Yang: research design, thesis supervision, revision and review.

Funding

This project was supported by the Science and Technology Aid Program (2022E02046) and the Graduate Student Innovation and Entrepreneurship Program (CXCY2022009).

Declarations

Competing interests

The authors declare no competing interests.

Ethical statement

This study was approved by the Medical Ethics Committee of the First Affiliated Hospital of Xinjiang Medical University (Approval No. K202301-27) without the need for written informed consent.

Additional information

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1038/s41598-025-85104-0>.

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