Correlation Between Serum Lactate Levels And Outcome In Pediatric Patients Undergoing Congenital Heart Surgery

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Background: Systemic hypoperfusion, hemodilution and tissue hypoxia increase lactate levels during cardiopulmonary bypass (CPB). The purpose of this retrospective study was to investigate the correlation between perioperative arterial lactate levels and morbidity and mortality in children undergoing congenital heart surgery.

Methods: This study was approved by the institutional Ethics Committee. A total of 236 patients who underwent congenital heart surgery between June 2014 - May 2016 were included. Arterial blood gas analysis lactate results at baseline, cooling and warming-up phases during CPB, sternal closure, and 0, 6, 12, and 24th hour in the ICU were recorded. The patients were divided into two groups based on highest recorded lactate levels: Group 1 (lactate < 4.5 mmol/L, n=183) and Group 2 (lactate ≥ 4.5 mmol/L, n=53). Demographic data, RACHS-1 (Risk Adjusted Classification for Congenital Heart Surgery) score, anesthesia, surgery, CPB and aortic cross-clamp times, Vasoactive - Inotropic Score at postop. 1h, blood product use (24h.), durations of mechanical ventilation, ICU and hospital stay, complications, sepsis, multiple organ dysfunction, surgical revision, and 30-day mortality were compared between the two groups .

Statistical analysis

SPSS for Windows version 21.0 was used. Lactate ≥ 4.5 mmol/L showed the area under the ROC curve to predict 30-day mortality (ROC area: 0.854; 95% CI: 0.761–0.948) with sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and test validity of 88.2%, 82.6%, 28.3%, 98.9% and 83%, respectively.

Characteristic variables	Group 1 (n=183)	Group 2 (n=53)	p
Age (Month)	42 (1 d - 204 m)	30 (2 d - 180 m)	0.256
Gender (M/F)	89 / 94	32 / 21	0.160
BSA (kg/m²)	0.58 (0.22-2)	0.56 (0.14-1.58)	0.337
Cyanotic (n, %)	45 (24.6)	24 (45.3)	0.006
RACHS-1 (n, %)			
I	47 (25.7)	5 (9.4)	< 0.001
II	83 (45.4)	21 (39.6)	
III	48 (26.2)	12 (22.6)	
IV	4 (2.2)	11 (20.8)	
V	1 (0.5)	2 (3.8)	
VI	0 (0)	2 (3.8)	

Table 1. Patient characteristics. Data are presented as median (minimum-maximum) or numerous (%)

	Group 1 (n,%)	Group 2 (n,%)
Non-cyanotic		
Atrial Septal Defect (ASD)	47 (25.7)	5 (9.4)
Ventricular Septal Defect (VSD)	37 (20.2)	5 (9.4)
ASD+VSD	12 (6.6)	1 (1.9)
Atrioventricular canal defect	9 (4.9)	2 (3.8)
Pulmonary stenosis	12 (6.6)	5 (11.3)
Pulmonary regurgitation	4(2.2)	4 (7.5)
Systemic valve stenosis	11 (6)	5 (9.4)
Left ventricular outflow obstruction	5 (2.7)	1 (1.9)
Cornary Anomalies (ALCAPA)	2 (1.1)	0 (0)
Cyanotic		
Tetralogy of Fallot	23 (12.5)	3 (5.7)
Single ventricle	4 (2.2)	4 (5.7)
Anomalous pulmonary venous return	4 (2.2)	1 (1.9)
Truncus arteriosus	0 (0)	2 (3.8)
Transposition of the great arteries	4 (2.2)	11 (20.7)
Double outlet right ventricle	7 (3.8)	1 (1.9)
Ebstein Anomaly	2 (1.1)	1 (1.9)
Hypoplastic left heart	0 (0)	2 (3.8)
Total (%)	183 (100)	53 (100)

Table 2. Diagnosis of patients. Abbreviations: ALCAPA; Anomalous left coronary artery from the pulmonary artery.

		Baseline	CPB cooling	CPB warming	Sternal closure
Lactate (mmol/L)					
	Group 1	0.94 (0.07-3.94)	2.62±0.96	2.28±0.84	1.9 (0.67-4.5)
	Group 2	1.58 (0.7-4.01)	4.02±1.13	4.58±1.55	4.45 (1.1-10.4)
	P	<0.001	<0.001	<0.001	<0.001
Mean Arterial Pressure (mmHg)					
	Group 1	80±16	52±10	65 (30-80)	66±10
	Group 2	72±21	54±12	66 (40-80)	66±13
	P	0.007	0.127	0.681	0.768
Heart Rate (bpm)					
	Group 1	126±24			115±19
	Group 2	128±29			117±20
	P	0.685			0.964
Central venous pressure (mmHg)					
	Group 1	10 (0-18)			11±3.8
	Group 2	9 (1-16)			11±4.1
	P	0.242			0.389
SpO ₂ (%)					
	Group 1	99 (74-100)			97±3
	Group 2	99 (75-100)			95±5
	P	0.54			0.265
Arterial PH					
	Group 1	7.42 (7.11-7.58)	7.34±0.07	7.37±0.08	7.37±0.05
	Group 2	7.42 (7.2-7.52)	7.36±0.08	7.4±0.12	7.36±0.06
	P	0.210	0.121	0.086	0.093
PaCO ₂ (mmHg)					
	Group 1	28 (18-73)	36±7	36±9	32 (24-57)
	Group 2	29 (21-55)	35±9	33±11	32 (18-58)
	P	0.221	0.165	0.062	0.969
PaO2 (mmHg)					
	Group 1	223 (28-596)	196±78	228±82	238±136
	Group 2	173 (25-576)	213±66	223±63	228±145
	P	0.151	0.116	0.706	0.752
Hematocrit (%)					
	Group 1	34 (22-57)	26 (17-44)	26 (18-40)	29 (20-43)
	Group 2	35 (27-53)	25 (19-40)	25 (19-37)	30 (18-41)
	P	0.210	0.535	0.783	0.887
Arterial Glucose (mg/dL)					
	Group 1	92±25	198 (62-366)	224±55	198 (94-359)
	Group 2	96±30	203 (127-395)	230±31	198 (132-404)
	P	0.380	0.282	0.262	0.432

Table 3. Intraoperative hemodynamic parameters and arterial blood gas results Data are presented as mean ± standard deviation, median (minimum-maximum).

	Group 1 (n=183)	Group 2 (n=53)	p-value
Duration of surgery (min)	219±52.4	255±52.8	< 0.001
Duration of anesthesia (min)	269±58	315±58	<0.001
CPB time (min)	65.5 (19-198)	90 (27-162)	< 0.001
Aortic cross-clamp time (min)	51 (0-181)	73 (0-160)	< 0.001
Vasoactive-Inotropic score	5 (0-40)	7.5 (0-70)	0.004
Duration of MV (hour)	4.5 (1.5-1080)	6.5 (1.5-792)	0.008
Duration of ICU stay (hour)	23 (16-1968)	29 (12-1680)	0.064
Length of stay in hospital (day)	7 (4-91)	8 (2-92)	0.019
Use of ES (mL)	135 (0-715)	175 (0-845)	0.114
Use of FFP (mL)	192 (0-960)	300 (0-1005)	0.053
Use of thrombocyte (mL)	20 (0-340)	30 (0-644)	0.097

Table 4. Intraoperative and postoperative variables of the patients. Data are presented as mean ± standard deviation, median (minimum-maximum).

Reference: Schumacher KR, Reichel RA, Vlasic JR, et al. Rate of increase in serum lactate level risk stratifies infants after surgery for congenital heart disease. J Thorac Cardiovasc Surg. 2014;148:589-95.

Figure 1. Perioperative lacate levels.(y- axis lactate in mmol L⁻¹; and x-axis time in lactate analysis. *p<0.001)

Results: A total of 53 patients (22.5%) had lactate levels of ≥ 4.5 mmol/L. There was a correlation between increased lactate levels and high RACHS-1 and inotropic scores, being cyanotic and increased durations of CPB, aortic clamp, surgery and anesthesia. At least one complication development (p=0.027) and mortality rate (p<0.001) were significantly higher in patients with lactate levels ≥ 4.5 mmol/L. 17 patients (7.2%) died during the postop. period, and 15 of them had lactate ≥ 4.5 mmol/L at least once within the first 24 hours. Lactate levels ≥ 4.5 mmol/L at any time, prolonged mechanical ventilation (>48 h), and complex surgery (RACHS-1 4-6) were independent risk factors for mortality.

	G roup1 (n, %)	Group 2 (n, %)	p
Respiratory	29 (15.8)	22 (41.5)	<0.001
Cardiac	43 (23.5)	27 (50.9)	<0.001
Neurological	6 (3.3)	11 (20.8)	<0.001
Renal	11 (6)	15 (28.3)	<0.001
Gastrointestinal	9 (5)	6 (11.3)	0.110
Hematologic	12 (6.6)	15 (28.3)	<0.001
MODS	6 (3.3)	14 (26.4)	<0.001
Sepsis	9 (5)	7 (13.2)	0.057
Revision	6 (3.3)	9 (17)	0.001
Mortality	2 (1.1)	15 (28.3)	<0.001

Table 5. Postoperative. complications, n; number of patients . MODS; Multiple organ dysfunction syndrome

Conclusion: In pediatric patients undergoing congenital heart surgery, high RACHS-1 score, high inotropic score, being cyanotic, prolonged CPB, aortic cross-clamp, surgery and anesthesia durations increase lactate levels. In the present study, lactate ≥ 4.5 mmol/L, high RACHS-1 score (4-6), and duration of mechanical ventilation (> 48 h.) were independent risk factors for mortality.