



Early Hemodynamic Profile in Critically Ill Patients with COVID-19

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Letter to the Editor

COVID-19 was declared by the World Health Organization as a “Public Health Emergency of International Concern” [1]. These patients may develop shock due to sepsis or cardiac injury; however, hemodynamic characteristics have not been described.

We analyzed the hemodynamic profile of 2 ventilated patients (critical cases), 2 non-ventilated patients with severe pneumonia (severe cases) and 1 patient with pneumonia (moderate cases) admitted to the ICU of the Tropical Medicine Institute “Pedro Kouri”, Havana, Cuba. SARS-CoV-2 infection was confirmed in all cases by reverse-transcriptase-polymerase-chain-reaction at hospital admission. Non-invasive hemodynamic measures (within the first 24 h of ICU admission) were used in order to minimize viral transmission to health-care provider. Arterial and central venous samples were simultaneously collected for testing. Fick method was used to calculate the Cardiac Output (CO) as $CO = VO_2 / Ca - CVO_2$, where VO_2 is the oxygen consumption (using the Bergstra's formula) and $Ca - CVO_2$ is the arterial-to-central venous oxygen content difference.

We observed a hyperdynamic profile, characterized by high CO and low systemic vascular resistance, in critical and severe cases; conversely, moderate cases have a normal hemodynamic pattern (Table 1). Of note, hyperdynamic changes were markedly higher for critical cases compared to those for severe cases, suggesting that a poor clinical course is associated with a more severe imbalance in hemodynamic parameters. Despite these finding, impairment in the mean arterial pressure was not observed in severe cases and low-dose norepinephrine was required in critical cases, indicating that tissue perfusion was guaranteed by the increased CO (Table 1).

Serum concentrations of inflammation-related biochemical markers were higher in patients with critical disease than those in patients with severe or moderate disease (Table 1), suggesting a close relationship between inflammation and hemodynamic imbalance. Angiotensin II effects are increased in COVID-19 patients because of a reduced activity in the angiotensin-converting enzyme 2, but inflammation-induced vasodilatation may overcome the Angiotensin II - associated vasoconstriction. In fact, Angiotensin II may be an inductor of inflammation and oxidative damage in early phases [2].

All patients had a central venous oxygen saturation >70% and central venous-to-arterial carbon dioxide difference (P_{cv-aCO_2}) <6.0 mmHg, indicating an adequate tissue oxygen supply and CO_2 wash-out, respectively; however, biological markers of anaerobic metabolism such as hyperlactatemia and $P_{cv-aCO_2} / Ca - cvO_2$ ratio >1.8 were observed in critical patients (Table 1). These findings suggest microcirculatory or mitochondrial disturbances [3].

In summary, this report highlights that in early phase of COVID-19-associated critical illness, patients show a hyperdynamic profile with microcirculatory/mitochondrial disturbances. These abnormalities may contribute to mortality.

Keywords: Cardiac output; COVID-19; Hemodynamics; Inflammation; SARS-CoV2; Shock.

References

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Table 1: Demographic, clinical and hemodynamic characteristics of patients at ICU admission.

Characteristic	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5
Age, years	87	68	56	71	76
Sex	Male	Female	Female	Male	Male
Body composition					
Weight, Kg	75	77	58	72	65
Height, meter	1.82	1.67	1.61	1.73	1.65
Body surface area, m ²	1.958	1.86	1.606	1.855	1.67
History of chronic disease	HBP	HBP	HBP, CKD	HBP, diabetes	HBP, CAD, cancer
Days from disease onset to ICU admission, days	10	7	9	7	8
Disease severity	Critical	Critical	Severe	Severe	Moderate
SAPS 3 score, points	81	58	44	67	66
SOFA score, points	9	8	3	2	1
Norepinephrine dose, µg/Kg/min	0.2	0.15	-	-	-
Respiratory rate, breath per minute	33	38	32	30	28
Mechanical ventilation	Yes	Yes	No	No	No
Arterial blood gases					
pH	7.25	7.38	7.42	7.41	7.42
SO ₂ , %	95.7	92.6	91.9	95.1	94.5
PO ₂ , mmHg	157.1	110.9	98.4	95.5	101.4
PaO ₂ /FiO ₂ ratio, mmHg	285.6	277.3	281.1	272.9	289.7
PCO ₂ , mmHg	41.3	27.2	28.9	33.5	34.7
HCO ₃ ⁻ , mmol/liter	18.5	15.7	18.2	21.1	21.9
CaO ₂ , ml/dl	17.67	12.26	15.82	11.77	13.23
Central venous blood gases					
p ^H	7.21	7.15	7.27	7.30	7.29
SO ₂ , %	83.6	89.6	78.4	75.6	71.3
PO ₂ , mmHg	58.4	58.2	56.1	53.4	49.8
PCO ₂ , mmHg	46.5	31.8	32.1	35.5	36.1
HCO ₃ ⁻ , mmol/liter	20.4	16.3	19.9	22.2	22.6
CvO ₂ , ml/dl	15.19	10.42	13.41	9.28	10.16
Combined blood gases analyses					
Ca-cvO ₂ , ml/dl	2.48	1.84	2.41	2.49	3.07
EO ₂ fraction, %	14.0	15.0	15.2	21.2	23.2
Pcv-aCO ₂ , mmHg	5.2	4.6	3.2	2.0	1.4
Pcv-aCO ₂ /Ca-cvO ₂ ratio, mmHg/ml/dl	2.1	2.5	1.33	0.80	0.46
Laboratory findings					
White-cell count, cells per mm ³	3.64	9.16	10.59	5.5	6.2
Total neutrophils	2.7	7.5	9.0	3.3	4.2
Total lymphocytes	0.65	1.2	0.95	1.54	1.67
Total monocytes	0.29	0.46	0.64	0.66	0.31
Platelet count, cells per mm ³	119	292	284	163	228
Hemoglobin, g/liter	13.4	9.6	12.6	9.0	10.2
Glycaemia, mmol/liter	7.0	7.7	7.5	6.11	6.54
Total proteins, g/liter	52.4	59.1	50.7	48.6	62.7
Albumin, g/liter	21.7	27.6	23.1	30.8	33.4
Globulins, g/liter	26.4	29.7	25.8	17.7	28.7
Bilirubin, µmol/liter	7.5	3.8	2.4	15.8	13.7

Alanine aminotransferase, U/liter	14.5	56.3	14.7	51.7	20.1
Aspartate aminotransferase, U/liter	17.2	140.2	35.3	28.4	15.0
Gamma-glutamyl transpeptidase, U/liter	27.1	410.2	142.0	212.2	27.0
Alkaline phosphatase, mmol/liter	47.8	161.0	102.3	239.3	80.0
Colesterol, mmol/liter	3.33	3.59	5.24	2.77	4.67
Triglycerides, mmol/liter	1.25	0.84	2.11	2.39	0.71
Creatinine, μ mol/liter	245.6	83.6	172.5	45.3	62.0
Urea, mmol/liter	18.2	5.9	8.7	2.4	7.4
Uric acid, μ mol/liter	583.7	273.1	445.7	243.5	232.0
Prothrombin time, seconds	14.9	13.9	13.4	11.9	14.2
International normalized ratio	1.07	0.99	0.91	0.81	1.01
Activated partial-thromboplastin time, seconds	26.1	20.8	37.4	26.4	34.9
d-dimer, μ g/ml	7.71	5.50	1.19	1.37	1.05
Ferritin, μ g/liter	1431.3	1345.9	796.7	191.7	121.0
High-sensitivity C-reactive protein, mg/liter	213.7	434.9	247.0	26.9	38.9
Lactic dehydrogenase, U/liter	277.8	496.4	527.4	443.1	204.0
Lactate, mmol/liter	2.2	2.0	1.9	1.1	0.9
Hemodynamic parameters					
Blood pressure, mmHg					
Systolic	112	116	121	132	138
Diastolic	58	61	66	67	71
Mean	76	79	84	89	93
Heart rate, beat per min	63	94	69	76	75
Central venous pressure, mmHg	8	7	5	4	7
Oxygen consumption, ml/min	275.9	253.1	215.2	261.8	232
Cardiac output, liter/min	11.1	13.8	8.9	10.5	7.6
Cardiac index, liter/min/m ²	5.68	7.39	5.56	5.67	4.4
Stroke volume, ml/beat	176.6	146.3	129.4	138.3	100.8
Stroke volume index, ml/beat/m ²	90.2	78.7	80.6	74.6	58.7
Systemic vascular resistance, dynes ⁵ sec ⁵ cm ⁵	490	417	710	648	905
Mortality	Yes	Yes	No	No	No

HBP: High Blood Pressure; CAD: Coronary Artery Disease; CKD: Chronic Kidney Disease; EO₂: Oxygen Extraction Fraction; SAPS: Simplified Acute Physiology Score; SOFA: Sequential Organ Failure Assessment