Microcirculatory alterations after cardiopulmonary bypass as assessed with near infrared spectroscopy: a pilot study

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To the Editor,

Cardiac surgery under cardiopulmonary bypass (CPB) may induce changes in microvascular perfusion and compromise peripheral tissue oxygenation.^{1,2} Near infrared spectroscopy (NIRS) is an easily applicable noninvasive technique that has been used in combination with the vascular occlusion technique (VOT) for the evaluation of the microcirculation.^{3,4} We hypothesized that NIRS and VOT are able to detect the microcirculatory alterations of cardiac surgical patients.

After obtaining institutional ethics approval and written informed consent, we conducted a pilot study in nine cardiac surgery patients (three males/ six females). Characteristics of the patients were: age 67 (13), EuroSCORE 6.4 (3.8), left ventricular ejection fraction 58 (9) %, CPB duration 129 (47) min, aortic cross-clamp time 66 (20) min. All patients were anesthetized and their lungs ventilated in a similar manner throughout the monitoring period. The doses of vasopressors/inotropes and propofol did not change during the monitoring period. Near infrared spectroscopy measurements were performed (InSpectra; Hutchinson Technology, Hutchinson, MN, USA) on the day prior to surgery,

postoperatively on admission to the intensive care unit, and every two hours for six hours. Tissue oxygen saturation (StO₂%) of the thenar eminence was monitored and a brachial VOT was utilized to better assess the microcirculation with the calculation of the oxygen consumption rate and the reperfusion rate.

The results of this pilot study are shown in the accompanying Table. Immediately after CPB there were abnormalities in skeletal muscle tissue oxygenation and utilization which normalized at six hours (Table A). Conversely, the global hemodynamic variables did not change significantly in this six-hour monitoring period (Table B).

This pilot study indicates that NIRS can detect microvascular derangements whereas routine global measurements seem to be insensitive.

Cardiac surgery with CPB induces physiological alterations:⁵ the blood is exposed to artificial surfaces, non-pulsatile flow is the norm, the myocardium is arrested with cold cardioplegic protection, and body temperature is lowered by several degrees. These features, in combination with the surgical trauma, contribute to an intense inflammatory reaction resulting in the activation of endothelial cells, leukocytes, platelets, the complement system, and the coagulation cascade. Endothelial dysfunction and the loss of endothelium-dependent vasodilation can lead to the “no-reflow” phenomenon and amplify tissue injury. This report shows that NIRS-derived variables depict this local derangement. The improvement of microcirculatory indices during the ensuing hours can be attributed to the restoration of the microcirculation as the hours after surgery progress. Importantly, this report also shows that routine monitors do not reflect these microvasculature abnormalities.

Future studies are needed to investigate the possibility of reversing these NIRS-derived microcirculation variables and whether these are important clinical end points.

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Table A Microcirculation variables assessed preoperatively, after admission to the intensive care unit (H₀), and every two hours for six hours (H₂, H₄, H₆)

	Preoperatively H _{pre}	After admission to ICU (H ₀), and every two hours up to six hours				
		H ₀	H ₂	H ₄	H ₆	P value
Thenar StO ₂ (%)	80 (4)	84 (5)	87 (5)	87 (6)	89 (4) ^{††††}	< 0.001
O ₂ consumption rate (%•min ⁻¹)	30 (11)	16 (10) ^{††}	20 (10)	24 (12)	29 (16)	0.002
Reperfusion rate (%•min ⁻¹)	655 (257)	216 (165) [†]	358 (227) ^{†††}	435 (211)	537 (297)	0.004

ICU = intensive care unit; StO₂ = tissue oxygen saturation. [†]P < 0.01 from H_{pre}; ^{††}P < 0.05 from H_{pre}; ^{*}P < 0.01 from H₀; ^{**}P < 0.05 from H₀. Data presented as mean (standard deviation)

Table B Hemodynamic data, pressures, lactate concentrations, and temperatures after ICU admission (H₀) and every two hours for six hours (H₂, H₄, H₆)

	H ₀	H ₂	H ₄	H ₆	P value
CO(L•min ⁻¹)	4.2 (1.1)	4.7 (1.3)	4.4 (0.6)	4.9 (1.1)	
CI (L•min ⁻¹ •m ⁻²)	2.3 (0.6)	2.7 (0.8)	2.5 (0.3)	2.8 (0.7)	
PCWP (mmHg)	11 (4.6)	12.5 (4.1)	10.5 (3.8)	11.2 (6)	
CVP (mmHg)	7.2 (4.3)	8.9 (3.9)	8.7 (3.8)	9 (4.4)	
SVR (dynes-s/cm ⁵)	1,520 (482)	1,189 (393)	1,277 (321)	1,162 (347)	0.035
PVR (dynes-s/cm ⁵)	249 (95)	189 (73)	350 (301)	219 (61)	
SvO ₂ (%)	69 (7)	66 (8)	64 (8)	65 (10)	
ScvO ₂ (%)	72 (8)	68 (9)	66 (10)	68 (10)	
Hb (mmol•L ⁻¹)	7.4 (1.1)	7.1 (1.1)	7 (1.4)	6.9 (1.1)	
Lac (mg•dL ⁻¹)	2.9 (2.2)	3.5 (2.9)	3.8 (3.1)	3.9 (2.7)	0.042
MAP (mmHg)	83 (13)	74 (11)	78 (16)	76 (12)	
MPP (mmHg)	22 (7)	23 (6)	28 (16)	24 (8)	
Central temperature (°C)	36.4 (0.7)	36.9 (0.6)	37.5 (0.4) ^{**}	37.8 (0.4) ^{**}	< 0.001
Peripheral temperature (°C)	35.8 (0.7)	36.3 (0.6)	36.9 (0.6) [§]	37.2 (0.5) [§]	< 0.001
Central-Peripheral temperature (°C)	0.53 (0.39)	0.42 (0.19)	0.52 (0.29)	0.45 (0.24)	

CI = cardiac index; CO = cardiac output; CVP = central venous pressure; Hb = hemoglobin; ICU = intensive care unit; Lac = lactate; MAP = mean arterial pressure; MPP = mean pulmonary pressure; PCWP = pulmonary capillary wedge pressure; PVR = pulmonary vascular resistance; ScvO₂ = central venous oxygen saturation; SvO₂ = mixed venous oxygen saturation. SVR = systematic vascular resistance, temp = temperature. ^{*}P < 0.01 from H₀; ^{**}P < 0.05 from H₀; [§]P < 0.01 from H₂; Data presented as mean (standard deviation)

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References

1. Bouchet JB, Durand E, Morel J, et al. Microcirculatory dysfunction after cardiac surgery: interest of NIRS technology with two case reports (French). *Ann Fr Anesth Réanim* 2011; 30: 589-93.
2. Uilkema RJ, Groeneveld AB. Correlates of thenar near-infrared spectroscopy-derived tissue O₂ saturation after cardiac surgery. *Interact Cardiovasc Thorac Surg* 2007; 6: 265-9.
3. Nanas S, Gerovasili V, Renieris P, et al. Non-invasive assessment of the microcirculation in critically ill patients. *Anaesth Intensive care* 2009; 37: 733-9.
4. Gerovasili V, Tripodaki E, Karatzanos E, et al. Short-term systemic effect of electrical muscle stimulation in critically ill patients. *Chest* 2009; 136: 1249-56.
5. McGuinness J, Bouchier-Hayes D, Redmond JM. Understanding the inflammatory response to cardiac surgery. *Surgeon* 2008; 6: 162-71.