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ORIGINAL

Regional oxygen saturation index (rSO_2) in brachioradialis and deltoid muscle. Correlation and prognosis in patients with respiratory sepsis

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KEYWORDS
Microcirculation;
Spectroscopy;
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Tissue oxygenation

Abstract
Objective: To compare oxygen saturation index (rSO_2) obtained simultaneously in two different brachial muscles.
Design: Prospective and observational study.
Setting: Intensive care unit.
Patients: Critically ill patients with community-acquired pneumonia.
Interventions: Two probes of NIRS device (INVOS 5100) were simultaneously placed on the brachioradialis (BR) and deltoid (D) muscles.
Variables: rSO_2 measurements were recorded at baseline (ICU admission) and at 24 h. Demographic and clinical variables were registered. Pearson's correlation coefficient was used to assess the association between continuous variables. The consistency of the correlation was assessed using the intraclass correlation coefficient (ICC) and Bland–Altman plot. The predictive value of the rSO_2 for mortality was calculated by ROC curve.
Results: Nineteen patients were included with an ICU mortality of 21.1%. The rSO_2 values at baseline and at 24 h were significantly higher in D than in BR muscle. Values obtained simultaneously in both limbs showed a strong correlation and adequate consistency: BR ($r = 0.95$; $p < 0.001$; ICC = 0.94; 95% CI: 0.90–0.96; $p < 0.001$), D ($r = 0.88$; $p = 0.01$; ICC = 0.88; 95% CI: 0.80–0.90; $p > 0.001$) but a wide limit of agreement. Non-survivors had rSO_2 values significantly lower than

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survivors at all times of the study. No patient with rSO_2 >60% in BR died, and only 17.6% died with an rSO_2 value >60% in D. Both muscles showed consistent discriminatory power for mortality.
Conclusion: Both BR and D muscles were appropriate for measuring rSO_2.

PALABRAS CLAVE
Microcirculación;
Espectroscopia cercana al infrarrojo;
Neumonía comunitaria;
Oxigenación tisular

Índice de saturación tisular de oxígeno en los músculos braquiorradial y deltoides. Correlación y pronóstico en pacientes con sepsis respiratoria

Resumen
Objetivo: Comparar el índice de saturación tisular de oxígeno (rSO_2) medido de forma simultánea en 2 diferentes músculos braquiales.
Diseño: Estudio prospectivo, observacional.
Ámbito: Servicio de Medicina Intensiva.
Pacientes: Críticos con neumonía comunitaria.
Intervenciones: Dos sensores con tecnología NIRS (INVOS™ 5100) fueron ubicados de forma simultánea en los músculos braquiorradial (BR) y deltoides (D).
Variables: Las mediciones del rSO_2 se efectuaron al ingreso (basal) y a las 24 h. Se registraron los datos demográficos y clínicos. La correlación de Pearson se utilizó para estudiar la asociación entre variables continuas. La concordancia de la correlación fue valorada mediante el coeficiente de correlación intraclase (ICC) y el análisis de Bland-Altman. El valor predictivo de rSO_2 para mortalidad fue calculado mediante curva ROC.
Resultados: Se incluyeron 19 pacientes con una mortalidad de 21,1%. El valor basal y a las 24 h de rSO_2 fue significativamente mayor en D respecto del BR. Los valores obtenidos de forma simultánea en ambos miembros evidenciaron una buena correlación y una adecuada concordancia: BR ($r = 0,95$; $p < 0,001$. ICC = 0,94; IC 95%: 0,90-0,96; $p < 0,001$), D ($r = 0,88$; $p = 0,01$. ICC = 0,88; IC 95%: 0,80-0,90; $p < 0,001$), así como un amplio rango de concordancia. Los fallecidos presentaron valores de rSO_2 significativamente menores que los supervivientes en todos los momentos del estudio. Ningún paciente con $rSO_2 > 60\%$ en BR falleció, y solo el 17,6% fallecieron con un $rSO_2 > 60\%$ en D. Ambos músculos evidenciaron un buen poder de discriminación para mortalidad.
Conclusiones: Tanto el músculo BR como el D fueron apropiados para la medición del rSO_2.

Introduction

Near-infrared spectrometry (NIRS) is a non-invasive technique that uses the differential absorption properties of oxygenated and deoxygenated haemoglobin to evaluate skeletal muscle oxygenation. This technique allows the assessment of the concentration of saturated haemoglobin and myoglobin and, indirectly, provides information about the state of the microcirculation. Two different primary variables can be obtained, depending on the device used: tissue oxygenation saturation (StO_2)[1,2] and regional oxygen saturation index (rSO_2).[3,4]

Skeletal rSO_2 muscle is equivalent to StO_2. However, StO_2 is defined as a quantification of the OxyHb/HbT ratio in microcirculation of skeletal muscle as an absolute number. On the other hand, skeletal rSO_2 is an index of OxyHb present within a volume of tissue; this index is expressed as the percentage of oxygenated haemoglobin relative to total haemoglobin (HbO_2/Hb sum). The INVOS 510 devices employ reflectance mode probes that have one 1.5 mm optical fibre to illuminate the tissue and two optical fibres (30 mm and 40 mm) to detect the backscattered light from the tissue. The 40 mm separated fibre measures a greater and deeper tissue volume than the 30 mm separated fibre. The difference between the spectral absorbance measured with these two probing depths is used to calculate rSO_2.

Nevertheless, this technique has some difficulties, mainly due to the lack of signal processing and acquisition procedures standardization.[5,6] The first problem arises from the difficulty of establishing a relationship between the two variables and comparing data obtained with different devices.[7] Moreover, there is no standard application site for measurements. Therefore, using different muscles may derive different values of the variables. These differences might be related, to the local perfusion characteristics (including its response to different stimulus), the different metabolic functions and states, and the morphological characteristics of each muscle, among others. In this regard, Bezemer et al.[7] reported that forearm StO_2 is a more sensitive parameter to haemodynamic changes than thenar StO_2 and that the depth at which StO_2 is measured is of minor influence. On the other hand, Ikossi et al.[2] found no association between StO_2 and tissue oxygen pressure (measured directly with electrodes) in deltoid muscle. Recently, our group reported that a brachioradialis rSO_2 greater than 60% at ICU admission was associated with better outcome in septic patients.[3]