Case Report

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The Inability of Oxygen Saturation Monitoring in a Patient with Tattoo Undergoing Coronary Artery Bypass Graft Surgery: A Case Report

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ABSTRACT

Near-infrared spectroscopy (NIRS) offers the anaesthesiologist a non-invasive window to the microvasculature of the body. The use of NIRS as a level alarm for goal directed perfusion in cardiac surgery is suggested towards a more physiologic procedure. In our case, tattoos interfered in somatic NIRS monitoring reliability in a patient undergoing coronary artery bypass graft surgery. Regarding the somatic rSO_2 over the tattoo, values fluctuated continuously, whereas an error message appeared regularly on the screen, which advised the user to recheck the connections or replace the reusable parts. Despite taking all the essential measures and following the troubleshooting algorithms, no improvement was noted. However, when the sensor was placed over the right bicep area, the only area of the left upper arm without a tattoo, rSO_2 values were consistent. Nonetheless, the patient had an uneventful triple coronary artery bypass graft surgery. To the best of our knowledge, this is the first reported case of a tattoo implication in NIRS credibility. The pigments and color dyes are probably the primary contributors to this situation. Awareness must be raised concerning tattoos and anaesthesiologists should favor sites without tattoos and interpret values thoroughly. Furthermore, as clinicians go deeper into somatic NIRS monitoring, the technology should be improved and specifically calibrated for peripheral sites, with further clinical exploration being mandatory.

Keywords: Case Report; Tattoo; NIRS

Abbreviations: NIRS: Near-Infrared Spectroscopy; GDP: Goal Directed Perfusion; LVEF: Left Ventricular Ejection Fraction; rSO_2: Regional Oxygen Saturation

Case Report

Near-infrared spectroscopy (NIRS) offers the anaesthesiologist a non-invasive window to the microvasculature of the body. Cerebral oxygen monitoring is a standard of care but technological advancements also allow tissue oxygen monitoring over a peripheral non-cerebral bed, namely somatic oxygen monitoring. Regarding cardiac surgery patients, a systematic review demonstrated moderate associations between somatic NIRS and central hemodynamics parameters, while a correlation between postoperative acute kidney injury and somatic NIRS has additionally been stated. Thus, use of NIRS as a level alarm for goal directed perfusion (GDP) in cardiac surgery is suggested towards a more physiologic procedure. As far as tattoos is concerned, they slowly emerge in the anaesthesiology literature in parallel with their social popularity; from thermal burns during MRI to safety concerns for central neuraxial blocks over tattoos. In our case, tattoos interfered in somatic NIRS monitoring reliability. Thus, special care in such cases when a skin area is occupied by pigmentations should be given. A 43-years old male patient diagnosed with myocardial infraction was scheduled for coronary artery bypass graft surgery in November 2021. His medical history included arterial hy-

pertension, type 2 diabetes and smoking. The coronary angiogram revealed severe triple vessel disease and the echocardiogram showed interventricular septum hypokinesia and a left ventricular ejection fraction (LVEF) of 45%. On physical examination, a colorful sleeve tattoo over the left upper arm and shoulder was noted (Figure 1).

Figure 1: Sleeve tattoo over the left upper arm.

Upon arrival to the operating room the basic anaesthetic monitoring and a NIRS device (INVOS 5100C; Covidien, MA, USA) was applied. Subsequently, cerebral and somatic sensors were bilaterally placed over the frontotemporal area and deltoid muscles respectively. It was easily noticed that, even though the cerebral regional oxygen saturation (rSO_2) was normal, the left somatic rSO_2 over the tattoo fluctuated between 20% and 80%, whereas the right somatic rSO_2 was constant at 78%. An error message appeared regularly on the screen, which advised the user to recheck the connections or replace the reusable parts. Despite taking all the essential measures and following the troubleshooting algorithms, no improvement was noted. Throughout the procedure the left somatic rSO_2 was inconsistent, apart from when sensor was placed over the right bicep area; the only area of the left upper arm without a tattoo. Nonetheless, the patient had an uneventful triple coronary artery bypass graft surgery and was transferred to the intensive care unit. He was extubated in the evening and discharged to the general ward on the third postoperative day. His neurologic outcome was excellent with no neurocognitive decline In our case, tattoos caused an inability to accurately monitor the somatic rSO_2. NIRS monitoring is widely used, especially in patients with loss of hemodynamic coherence between macrocirculatory oxygen parameters and the peripheral microvasculature. Especially in cardiac surgery GDP is contemporarily comprises NIRS monitoring to secure optimal tissue perfusion [1].

Although literature review reveals conflicting data about NIRS-based algorithms, the 2019 guidelines on cardiopulmonary bypass include cerebral NIRS as a class IIb recommendation with a level B of evidence [2]. Within the NIR range (700 - 1300 nm) Hb, HbO2, bilirubin and cytochrome constitute the primary light-absorbing molecules, providing an interesting biological spectroscopic window, whereas other biological compounds have a flat absorption spectra [3]. The INVOSTM uses two wavelengths, 730 nm and 810 nm, where the absorption spectra of Hb and HbO2 is maximally separated. Photons are projected into the skin and a fraction of them returns to the detectors, after being scattered inside the tissues. The attenuation of light returning to the detectors is due to absorption of the chromophores present, according to the Beer-Lambert law. NIRS technology is commercially available since the 1990s; nevertheless, anaesthesiologists encounter unanticipated challenges concerning rSO_2 values. Thick skin or fat layers impede penetration of light; a 50% in NIR light absorbance has been observed with a fat tissue thickness increase from 5 to 10 mm [4]. A study in patients with dark color skin concluded that values should be meticulously interpreted in individuals with dark skin pigmentation, due to high melanin concentration [5]. Additionally, hyperbilirubinemia and icterus can produce inaccurate values, as bilirubin absorbs NIR light [4].

Another worth mentioning chromophore is myoglobin, which likewise absorbs a noteworthy amount of NIR when found in high

concentrations; for instance in rhabdomyolysis. In this situation Hb saturation will be overestimated, due to myoglobin's higher oxygen affinity compared to Hb.4 Moreover, alkaptonuria alters rSO_2 values, as the increased homogentisic acid, due to defects in phenylalanine and tyrosine metabolism, binds irreversibly to collagen in tissues and organs causing bluish-black pigmentation [6]. Selected of the above-mentioned situations are also found in the INVOS 5100C Operations Manual. Conclusively, NIRS monitoring does not provide an unbiased estimate of tissue saturation and is affected differently by specific patient characteristics. In our case, the somatic sensor placed over the tattoo was unable to measure the rSO_2. Such, a false signal may lead to suboptimal monitoring especially when NIRS is used as a GRD strategy; in patients like the one reported with impaired LVEF this information is highly valid. The tattoo substances interfered in the light penetration through the skin. Literature review reveals interesting facts about tattoo procedures and the pigments used. The tattooing process involves a needle penetrating the epidermis and the dermis, with pigment depositing along the entire needle tract. These pigments are specific solid particles which are blended with a diluent that allows easier transfer. Unfortunately, there is no regulation about the pigments' composition either by the US Food and Drug Administration or by European services.

Nowadays, the vast majority of the pigments are organic and may include dyes to provide a wider variety of color. However, many traditional tattoos artists prefer traditional pigments which include inorganic substances and heavy metals. Nonetheless, it is the case that sometimes neither the individual being tattooed, nor the tattoo artist know the exact composition of the ink [7]. The pigments in our patient's tattoos were most likely color dyes and heavy metal, which impeded NIR light penetration. To the best of our knowledge, this is the first reported case of a tattoo implication in NIRS credibility. The pigments and color dyes are probably the primary contributors to this situation. Awareness must be raised concerning tattoos and anaesthesiologists should favor sites without tattoos and interpret values thoroughly. Furthermore, as clinicians go deeper into somatic NIRS monitoring, the technology should be improved and specifically calibrated for peripheral sites, with further clinical exploration being mandatory.

Informed Consent

Informed consent to publication was obtained from the patient. A copy of the written consent is available for review.

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Conflicts of Interests

None.

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