Maastricht University

Non-invasive tissue oximetry

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Summary

The introduction of near-infrared spectroscopy for assessment of regional tissue oxygenation was an important landmark in the history of tissue perfusion monitoring. Since then, non-invasive tissue oximetry gained wide interest with subsequent studies addressing the clinical importance of continuous monitoring of tissue perfusion. An increasing amount of literature including many observational and few intervention-guided studies elucidated on the added value of primarily regional cerebral oximetry in terms of predicting neurologic outcome following cardiopulmonary bypass. Some studies even suggested that cerebral oximetry can be used as an organ index, meaning that maintaining adequate tissue oximetry levels is beneficial for all vital organs. Furthermore, continuous tissue oximetry proved to be a valuable addition in various clinical applications (short-term and prolonged cardiopulmonary support, and monitoring graft viability ensuing transplant surgery), as it effectively identifies changes in tissue oxygenation following several iatrogenic events.

Despite these proposed benefits, routine use of tissue oximetry in the clinical setting is, as of now, far from evident. For a compelling part this is due to the lack of well-designed interventional studies showing a clear association between tissue oximetry values and outcome, as well as discordance regarding clinically relevant and application-specific tissue oxygenation thresholds predictive for adverse outcome. Moreover, different applications of tissue oximetry require different interpretation strategies due to the absence or presence of regional vascular autoregulatory activity. Especially during cerebral oximetry, intact or any extent of temporary or permanently disturbed cerebral autoregulation directly affects oxygen delivery. In this case, assumptions as part of the algorithm used for calculation of oxygenated and deoxygenated hemoglobin may contribute to interpretation errors in apparent normal tissue oxygenation. Therefore, it remains of utmost importance to include all available clinical information when performing tissue oximetry.

Taking the aforementioned into account, non-invasive tissue oximetry aids in prompt assessment of tissue oxygenation and may thereby contribute to prevention of complications associated with hypoxia. The latter catalyzes indivertible developments for various prospective clinical applications.

Samenvatting

De introductie van nabij-infrarood spectroscopie voor het regionaal monitoren van weefseloxygenatie was een belangrijke mijlpaal in de geschiedenis van weefselperfusie monitoring. Sindsdien is non-invasieve weefseloxymetrie meer onder de aandacht gekomen en richten studies zich op het klinische belang van continue weefselmonitoring. Een toenemende hoeveelheid literatuur waarvan enkele interventionele en vele observationele studies focust op voornamelijk regionale cerebrale oxymetrie in de context van het voorspellen van neurologische complicaties na cardiopulmonale bypass. Sommige studies suggereren zelfs dat cerebrale oxymetrie als een orgaanindex kan worden toegepast, hetgeen betekent dat behoud van adequate weefseloxymetrie waarden gunstig zou zijn voor alle vitale organen. Continue weefseloxymetrie is een bewezen waardevolle aanvulling in verscheidene klinische toepassingen (kort- en langduringe cardiopulmonale ondersteuning en monitoren van de levensvatbaarheid van een transplantaat), daar het effectief blijkt in identificatie van veranderingen in weefseloxygenatie ten gevolge van verschillende iatrogene gebeurtenissen.

Ondanks deze voorgestelde voordelen is routinematig gebruik van weefseloximetrie in de klinische setting bij lange na niet vanzelfsprekend. De oorzaak hiervan kan deels gezocht worden in het gebrek aan correct opgezette interventionele studies die een duidelijke associatie tussen weefseloxymetrie waarden en relevante uitkomsten aantonen. Daarbij bestaat ook tegenstrijdigheid in klinisch relevante en applicatie-specifieke grenswaarden voor weefseloxygenatiewaarden die gelinkt zijn aan nadelige gezondheidseffecten. Tevens behoeven de verschillende afzonderlijke toepassingen van weefseloxymetrie verschillende interpretatiestrategieën vanwege de aan- of afwezigheid van regionale autoregulatoire vasculaire acitiviteit. Vooral bij cerebrale oxymetrie is intacte cerebrale autoregulatie, of een verstoring hiervan, direct van invloed op de zuurstofvoorziening van het brein. In beide gevallen dragen aannames, welke onderdeel uitmaken van het algoritme dat gebruikt wordt voor de berekening van geoxygeneerd en gedeoxygeneerd hemoglobine, bij aan interpretatiefouten bij ogenschijnlijk normale weefseloxygenatie waarden. Het is daarom van groot belang om rekening te houden met alle beschikbare klinische informatie bij het toepassen van weefseloxymetrie.

Met inachtneming van de voorgenoemde zaken kan gesteld worden dat noninvasieve weefseloxymetrie bijdraagt in directe beoordeling van weefseloxygenatie en daarbij preventie van complicaties ten gevolge van hypoxie. Laatsgenoemde katalyseert de onvermijdbare ontwikkeling van nieuwe klinische toepassingen.