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International Journal of Biomed Research

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Short Communication

Can near Infrared Spectroscopy Links Pharmacological effects and Their Reversal upon Haemoglobin to Cerebral Metabolism? A Research Proposal

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Received date: February 10, 2025; Accepted date: February 20, 2025; Published date: March 10, 2025

Citation: Francesco Crespi, (2025), Can near Infrared Spectroscopy Links Pharmacological effects and Their Reversal upon Haemoglobin to Cerebral Metabolism? A Research Proposal, *International Journal of Biomed Research*, 4(2): **DOI**:10.31579/2834-5029/084

Abstract

The "ph-NIRS" concept has been successively supported in translational studies when this methodology was applied to compare the effect of alcohol as well as nicotine smoke upon brain metabolism in rodents versus man (Crespi F et al. 2018A; Crespi. F. 2021A,B). In order to further validate the "pharmacological NIRS" concept experiments could be performed to analyse the effect of various treatments involving different specific influences upon brain activities.

Keywords: drug; pharmacology; neuropharmacology; biochemical

Introduction

Near infrared spectroscopy (NIRS) is a non invasive methodology (Jobsis F. 1977; Crespi F.2007) that has been shown able to to overcome the major limitation of invasive in vivo techniques to study brain activities in rodents as well as in man (Crespi et al. 2018A, Crespi 2021 A,B). NIRS is indeed a non-ionizing technique that can be used to monitor oxygen saturation in the living tissue as well as changes in oxygenation of haemoglobin (Jobsis 77;; Crespi et al. 2006, Obrigh 2014). In particular, the absorption spectra of near-infrared light differ for the oxygenation–deoxygenation states of haemoglobin (oxygenated form HbO2 vs. deoxygenated form Hb, respectively) so that the two compounds can be directly monitored. Accordingly, the total haemoglobin concentration (HbO2 + Hb) can be considered as total blood volume (THC) (Chia-Wei Sun & Ching-Cheng Chuang (2012). All together these measurements are indicative of the state of vascular activity and the state of the metabolism in the tissue analyzed. NIRS has been also recently indicated as valuable tool to monitor influence(s) of acute drug treatment(s) on metabolic activity of the brain (Crespi et al. 2018A,B). In particular, the "pharmacological NIRS" (ph-NIRS) concept has been initially proposed as result of experiments where rodents were treated with drugs of abuse (Crespi F. et al. 2006). Then the phNIRS concept was sustained within specific treatments with cocaine when parallel NIRS and magnetic resonance imaging (MRI) experiments were performed (Crespi F. et al. 2018B). The "ph-NIRS" concept has been successively supported in translational studies when this methodology was applied to compare the effect of alcohol as well as nicotine smoke upon brain metabolism in rodents versus man (Crespi F et al. 2018A; Crespi. F. 2021A,B). In order to further validate the "pharmacological NIRS" concept experiments could be performed to analyse the effect of various treatments involving different specific influences upon brain activities.

In particular, the specific analysis of pharmacological effect(s) upon NIRS parameters of selective neurotrasmitter receptor agonist(s) as well as the selective receptor antagonist(s), respectively can be proposed.

For istance, neurotrasmitter systems such as dopamine and serotonin systems would be tackled with receptor agonist and – or receptor antagonist., i.e.

a) Concerning the dopamine (DA) system: cocaine as DA receptor agonist and the selected D3 dopamine receptor antagonist SB-277011-A can be selected, while
b) Concerning the serotonin (5-HT) system: 8-OH-DPAT a 5-HT receptor agonist and 5-HT receptor antagonists (I.e. the 5-HT1A antagonist Way 100635) can be used. Specifically, these two neurotransmitter systems and therefore the chemicals proposed for the proposed study are selected based upon their well known influence – effect upon the vascular system (McBean et al. 1991; Kaufman et al. 1998; Tiniakov et a. 2012; Rapoport et al. 2016).

Briefly:

a) Concerning the dopamine (DA) system:

Experiments will be performed in anaesthetized rats treated i.e. with cocaine alone or preceded by treatment with the selective D3 receptor antagonist SB-277011-A as described earlier (Congestri et al. 2008).

These experiments will be useful to reveal the possibility of using NIRS to detect i.e. the putative efficacy of the D3 receptor antagonist on modifying the effect of cocaine upon brain metabolism.

In addition, confirmation of specificity of NIRS evaluations could be performed comparing the efficacy of a selective versus non selective D3 receptor antagonists (for a review Smith et al. 2012) on the effect of cocaine upon brain metabolism.

b) Concerning the 5-HT system:

The vasoconstriction effect of 5-HT receptor agonists such as 8-OH-DPAT (Garrat et al. 1989, Odland et al. 2021) could be monitored using NIRS as above. In particular, the treatment with this 5-HT 1A agonist should result in a significant decrease of total volume (HbT) monitored in the brain of anaesthetized rats. Then, the complete or partial blockade of such effect(s) with selective antagonist (i.e. Way 100635, Rabiner et al. 2002) could be supportive of the phNIRS concept.

c) A further kind of experiment will be analysing the influence of inflammatory process upon NIRS parameters i.e., via experiments studying the effect(s) of interleukin-1 and the respective antagonist (IL-Ira):

Experimental evidence indicates that interleukin-1 (cytokine IL-1) is a pivotal mediator of inflammation playing a major role in neuroinflammation (Basu et al. 2004) and in neurodegeneration (Simi et al. 2007). Furthermore, a major role of cytokines in the mechanism of action of HbO2 is proposed (Al-Waili & Butler 2006; Vinkel et al. 2023). The respective endogenous specific receptor antagonist (IL-Ira) (Dinarello 1998) is produced in numerous experimental animal models of disease as well as in human autoimmune and chronic inflammatory diseases (Arend et al. 1998) in which it has been shown to selectively inhibits the effects of IL1 (Schiff 2000) with possibly beneficial effect(s) upon human diseases (Hallegua & Weisman 2002). The NIRS analysis of the effect(s) of interleukin-1 as well as of IL-Ira or that a further compound such as anakinra, a recombinant human IL1 receptor antagonist (for a review Hallegua & Weisman 2002) will add knowledge on their putative influence upon brain HbO2. Altogether these experiments will be of help on confirming the "pharmacological NIRS" concept as proposed in previous work. Therefore this will improve the quality of NIRS analysis as qualitative and possibly also quantitative in vivo non invasive tool for studying brain metabolism in preclinical and possibly parallel traslational clinical work.

References

1. Jobsis F. (1977). Non invasive, infrared monitoring of cerebraland myo-cardial oxygen sufficiency and circulatoryparameters. *Science* 198: 1264-1267
2. Crespi F. (2007). Near-infrared spectroscopy (NIRS): a noninvasive in vivo methodology for analysis of brain vascular and metabolic activities in real time in rodents *Current Vascular Pharmacology*.5(4):305-321
3. Crespi F, Congestri F, Donini M (2018). Translational NIRS:Parallel Alteration of Brain Metabolism Following Alcohol Intake in Rodents and Man. *J Neurodegenerative Disorders*.2(1):22-31.
4. Crespi F. (2021). "Non-Invasive in Vivo Technologies for Translational Medicine Applications". *International Journal of Epidemiologyand Public Health Research*, 1(3).
5. Crespi, F. (2021). Influence of nicotine upon human brain metabolism, an in vivo noninvasive Near Infrared Spectroscopy (NIRS)study. *Clinical Research and Clinical Trials*. 4(4).
6. Crespi F., M. Donini, A. Bandera, F. Congestri, F. Formenti,V. et al. (2006). Near infrared oxymeterbiosensor-prototype for non-invasive in vivo analysis of ratbrain oxygenation: effects of drugs of abuse. *Journal ofOptics*: Pure and Applied Optics, vol8, #7, 528-534
7. Obrig H (2014). NIRS in clinical neurology – a 'promising'tool? *Neuroimage* 85: 535-546.
8. Chia-Wei Sun, Ching-Cheng Chuang (2012). Hemodynam-ics Study Based on Near-Infrared Optical Assessment. In:A Seda Artis, Hemodynamics – New diagnostic and therapeutic approaches. *InTech pub*, 47-89.
9. Crespi F, Formenti F, Congestri F. (2018). Near Infrared Spectroscopy alike Magnetic Resonance Imaging: Complementary Data in Rat Brain after Cocaine Treatment. *J.Neurodegenerative Disorders* 2(1):39-47
10. McBean, D. E., Sharkey, J., Ritchie, I. M., & Kelly, P. A. (1991). Cerebrovascular and functional consequences of 5-HT1A receptor activation. Brain research, 555(1), 159-163.
11. Kaufman, M. J., Levin, J. M., Ross, et al. (1998). Cocaine-induced cerebral vasoconstriction detected in humans with magnetic resonance angiography. *Jama*, 279(5), 376-380.
12. Tiniakov, R., Pahan, K., & Scrogin, K. E. (2012). Sympathetic innervation of the splanchnic region mediates the beneficial hemodynamic effects of 8-OH-DPAT in hemorrhagic shock. *American Journal of Physiology-Regulatory, Integrative and Comparative Physiology*, 303(5), R527-R538.
13. Rapoport, R. M., Yoon, S., & Zuccarello, M. (2016). Cocaine constrictor mechanisms of the cerebral vasculature. *Journal of Cardiovascular Pharmacology*, 67(5), 442-450.
14. Congestri F., F. Formenti, V. Sonntag, Crespi F. (2008). The Selective D3 Receptor Antagonist SB-277011-A Potentiates the Effect of Cocaine on Extracellular Dopamine in the Nucleus Accumbens: a Dual Core-Shell Voltammetry Study in Anesthetized Rats. Sensors 8: 6936-6951.
15. Smith, H. S., Cox, L. R., & Smith, B. R. (2012). Dopamine receptor antagonists. *Annals of Palliative Medicine*, 1(2):137-142.
16. Garrat J., Marsden C.A., Crespi F. (1989). 8 hydroxy-DPAT can decrease 5HT neuronal firing and release but not metabolism. *British Journal of Pharmacology* 96: 300.
17. Odland, A. U., Jessen, L., Kristensen, et al. (2021). The 5-hydroxytryptamine 2A receptor agonists DOI and 25CN-NBOH decrease marble burying and reverse 8-OH-DPAT-induced deficit in spontaneous alternation. *Neuropharmacology*, 183, 107838.
18. Rabiner, E. A., Messa, C., Sargent, et al. (2002). A database of [11C] WAY-100635 binding to 5-HT1A receptors in normal male volunteers: normative data and relationship to methodological, demographic, physiological, and behavioral variables. *Neuroimage*, 15(3), 620-632.
19. Basu, A., Krady, J. K., & Levison, S. W. (2004). Interleukin-1: a master regulator of neuroinflammation. Journal of neuroscience research, 78(2), 151-156.
20. Simi, A., Tsakiri, N., Wang, P., et al. (2007). Interleukin-1 and inflammatory neurodegeneration. Biochemical Society Transactions, 35(5), 1122-1126.
21. Al-Waili, N. S., & Butler, G. J. (2006). Effects of hyperbaric oxygen on inflammatory response to wound and trauma:

possible mechanism of action. *The Scientific World Journal*, 6(1), 425-441.

22. Vinkel, J., Arenkiel, B., & Hyldegaard, O. (2023). The mechanisms of action of hyperbaric oxygen in restoring host homeostasis during sepsis. *Biomolecules*, 13(8), 1228.
23. Dinarello, C. A. (1998). Interleukin-1, interleukin-1 receptors and interleukin-1 receptor antagonist. *International reviews of immunology*, 16(5-6), 457-499
24. Arend, W. P., Malyak, M., Guthridge, C. J., & Gabay, C. (1998). Interleukin-1 receptor antagonist: role in biology. Annual review of immunology, 16(1), 27-55.
25. Schiff, M. H. (2000). Role of interleukin 1 and interleukin 1 receptor antagonist in the mediation of rheumatoid arthritis. *Annals of the rheumatic diseases*, 59(suppl 1), i103-i108
26. Hallegua, D. S., & Wseisman, M. H. (2002). Potential therapeutic uses of interleukin 1 receptor antagonists in human diseases. *Annals of the Rheumatic Diseases*, 61(11), 960-968.