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HYPEROXIA TRIGGERS A BIPHASIC REDOX RESPONSE LEADING TO COGNITIVE IMPAIRMENT IN ADULT MICE

A HIPERÓXIA DESENCADEIA UMA RESPOSTA BIFÁSICA QUE LEVA AO COMPROMETIMENTO COGNITIVO EM CAMUNDONGOS ADULTOS

LA HYPEROXIA DESENCADENA UMA RESPUESTA REDOX BIFÁSICA QUE CONDUCE AL DETERIORO COGNITIVO EM RATONES ADULTOS

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ABSTRACT

Reactive oxygen species (ROS) are natural byproducts of aerobic metabolism, with mitochondria serving as a major source of their production. These highly reactive molecules increase during oxidative stress and brain injury. Normobaric 100% oxygen therapy is widely used to improve brain cell survival in neurological disorders; however, excessive O_2 exposure may impair antioxidant defenses, promote oxidative damage in hippocampal neurons, and contribute to cognitive deficits. Despite its clinical use, important aspects of

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normobaric hyperoxia remain unclear, including its therapeutic window, antioxidant response, effects on memory, and long-term consequences. This study investigated the effects of continuous exposure to 100% oxygen at normal atmospheric pressure on memory and hippocampal redox balance in adult male C57BL/6 mice. Animals were exposed to hyperoxia for 12 or 24 h, followed by evaluation of memory using the novel object recognition (NOR) test. Hippocampal superoxide dismutase (SOD) and catalase (CAT) activities, reduced glutathione (GSH), and malondialdehyde (MDA) levels were analyzed. Exposure to hyperoxia for 24 h impaired memory and increased GSH levels, whereas SOD activity and MDA levels were altered after both 12 and 24 h exposures. Overall, these findings demonstrate that 24 h of 100% oxygen exposure induces hippocampal redox imbalance, potentially contributing to neuronal damage and memory impairment.

Keywords: Hyperoxia. Brain. Memory. Behavior. Oxidative Stress.

RESUMO

As espécies reativas de oxigênio (EROs) são subprodutos naturais do metabolismo aeróbico, sendo as mitocôndrias uma das principais fontes de sua produção. Essas moléculas altamente reativas aumentam em condições de estresse oxidativo e lesão cerebral. A oxigenoterapia normobárica com 100% de oxigênio é amplamente utilizada para melhorar a sobrevivência celular em condições neurológicas; no entanto, a exposição excessiva ao O_2 pode comprometer as defesas antioxidantes, promover danos oxidativos em neurônios hipocampais e contribuir para déficits cognitivos. Apesar de seu uso clínico, aspectos importantes da hiperóxia normobárica ainda permanecem pouco esclarecidos, incluindo sua janela terapêutica, a resposta antioxidante, os efeitos sobre a memória e suas consequências em longo prazo. Este estudo investigou os efeitos da exposição contínua a 100% de oxigênio, em pressão atmosférica normal, sobre a memória e o equilíbrio redox hipocampal em camundongos machos adultos C57BL/6. Os animais foram expostos à hiperóxia por 12 ou 24 h, seguidos da avaliação da memória por meio do teste de reconhecimento de objeto novo (RON). Foram analisadas as atividades hipocampais das enzimas superóxido dismutase (SOD) e catalase (CAT), além dos níveis de glutationa reduzida (GSH) e malondialdeído (MDA). A exposição à hiperóxia por 24 h prejudicou a memória e aumentou os níveis de GSH, enquanto a atividade da SOD e os níveis de MDA foram alterados após 12 e 24 h de exposição. Em conjunto, esses achados demonstram que 24 h de exposição a 100% de oxigênio induzem desequilíbrio redox no hipocampo, potencialmente contribuindo para dano neuronal e prejuízo da memória.

Palavras-chave: Hiperóxia. Cerebro. Memória. Comportamento. Estresse Oxidativo.

RESUMEN

Las especies reactivas de oxígeno (EROs) son subproductos naturales del metabolismo aeróbico y aumentan en condiciones de estrés oxidativo y lesión cerebral. La oxigenoterapia normobárica con 100% de oxígeno se utiliza ampliamente en trastornos neurológicos; sin embargo, la exposición excesiva al O_2 puede comprometer las defensas antioxidantes y contribuir a déficits cognitivos. Este estudio investigó los efectos de la hiperoxia continua sobre la memoria y el equilibrio redox hipocampal en ratones machos adultos C57BL/6. Los animales fueron expuestos a hiperoxia durante 12 o 24 h y evaluados mediante la prueba de reconocimiento de objeto nuevo (NOR). Se analizaron las actividades de superóxido dismutasa (SOD) y catalasa (CAT), además de los niveles de glutatión reducido (GSH) y malondialdehído (MDA). La exposición durante 24 h deterioró la memoria y aumentó los

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niveles de GSH, mientras que la actividad de SOD y los niveles de MDA se alteraron tras 12 y 24 h. En conjunto, estos hallazgos demuestran que 24 h de exposición al 100% de oxígeno inducen desequilibrio redox hipocampal, potencialmente contribuyendo al daño neuronal y al deterioro de la memoria.

Palabras clave: Hiperoxia. Cerebro. Memoria. Comportamiento. Estrés Oxidativo.

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1 INTRODUCTION

Under normal physiological conditions, the human body relies on atmospheric oxygen (O_2), which constitutes 21% of air composition (IGHODARO; AKINLOYE, 2018; MACHADO et al., 2022; SHIN et al., 2007). This inhaled oxygen supports arterial O_2 saturation levels of 95 to 100% in healthy individuals (SHIN et al., 2007). In pathological hypoxic conditions, such as cerebral ischemia, traumatic injuries, and respiratory disorders, including COVID-19, supplemental oxygen is a frequently employed therapeutic intervention (ALVA et al., 2023; ISHIDA et al., 2021; NI et al., 2019; PERRONE; LASCHI; BUONOCORE, 2020). However, this practice carries the risk of hyperoxia if the arterial partial pressure of oxygen (PaO_2) exceeds 300 mmHg (NI et al., 2019), surpassing safe physiological limits.

Hyperoxia has been well-documented to enhance the generation of reactive oxygen species (ROS), thereby disrupting cellular homeostasis (ALVA et al., 2023). Although the body possesses an intricate antioxidant defense system that plays a critical role in maintaining redox balance (MACHADO et al., 2022; PERRONE; LASCHI; BUONOCORE, 2020), excessive exposure to hyperoxia can overwhelm these endogenous protective mechanisms. This condition results in ROS accumulation, leading to redox imbalance and cellular damage (PERRONE; LASCHI; BUONOCORE, 2020).

The brain is particularly vulnerable to oxidative stress compared to other tissues due to its high content of polyunsaturated lipids, elevated oxygen demand, and relatively low levels of antioxidant enzymes (NI et al., 2019). In brain areas such as the hippocampus, oxidative damage to neurons can impair synaptic structures, cognitive functions, and memory (BREHMER et al., 2012). Memory, which encompasses the acquisition, retention, and recall of information, naturally declines with brain aging (SCHNEIDER et al., 2021; SHRESTHA; KLANN, 2016). However, factors such as an altered redox state in the hippocampus may accelerate this cognitive decline (NI et al., 2019). Reactive oxygen species can compromise neuronal integrity in the hippocampus by damaging cell membranes, proteins, and DNA, ultimately leading to cell death and the disruption of synaptic connections crucial for memory preservation (BREHMER et al., 2012). Given the brain's susceptibility to oxidative stress, it is conceivable that hyperoxia may induce oxidative damage in hippocampal neurons.

Thus, we hypothesize that exposure to hyperoxia elicits oxidative damage in the hippocampus, leading to memory impairment. Therefore, this study aimed to investigate the

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impact of 12 and 24 h of hyperoxia on cognitive function and hippocampal redox homeostasis in mice.

2 MATERIALS AND METHODS

2.1 ANIMALS

Forty adult male C57BL/6 mice (8–12 weeks old) were obtained from the Animal Science Center of the Federal University of Ouro Preto (UFOP) and housed under standard conditions (22 ± 2 °C) with ad libitum access to food and water. All procedures followed the Guide for the Care and Use of Laboratory Animals (US National Academy of Sciences) and were approved by the UFOP Ethics Committee (CEUA nº 3864110820). The study was conducted once, minimizing animal use and suffering. Mice were randomly assigned to three groups (n = 10/group):

(1) Spontaneous ventilation for 12 h (SV12);
(2) Hyperoxia for 12 h (H12);
(3) Hyperoxia for 24 h (H24).

2.2 HYPEROXIA PROTOCOL

Medical-grade O_2 (8000 L; White Martins, Brazil) was delivered via a Bourdon and Thorpe tube system (0–15 L/min) into a sealed acrylic chamber (20 × 15 × 30 cm) through a silicone conduit, as previously described (Bezerra et al., 2019). O_2 concentration was continuously monitored with a C3 oxygen sensor (Middlesbrough, UK) (NAGATO ET AL., 2012). After exposure, animals were immediately tested in the Novel Object Recognition task.

2.3 NOVEL OBJECT RECOGNITION TEST (NOR)

Recognition memory was assessed using the Novel Object Recognition (NOR) test, based on the innate rodent preference for novelty (DE PAULA ET AL., 2021). Sessions occurred between 2–5 p.m., with 1 h habituation to the testing room. The task was performed in an open field arena. After habituation, animals explored two identical objects for 5 min (training), followed 30 min later by a 5-min test phase where one object was replaced by a novel one (DE PAULA ET AL., 2021). Exploration was defined as sniffing or touching objects and Exploration time was recorded, and discrimination indexes (DI) were calculated as

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$$DI = \frac{Tnovel}{Total} x\ 100 \quad \text{and} \quad DI = \frac{Tfamiliar}{Total} x\ 100 \qquad (1)$$

Where:

Tnovel = time spent exploring the new object

Tfamailar = time spentexploring the familiar object

Ttotal = full exploration time

2.4 TISSUE PROCESSING AND HOMOGENIZATION

Mice were euthanized by cervical dislocation and transcardial perfusion with ice-cold saline. Brains were rapidly removed, and the hippocampi were dissected and isolated from the cerebral hemispheres. Tissue samples were then homogenized in phosphate buffer (pH 7.2) and stored at -80 °C until further analysis.

2.5 ANTIOXIDANT ENZYMES AND BIOMARKERS OF OXIDATIVE DAMAGE

Hippocampal homogenates were used for biochemical analyses. SOD activity was determined by the inhibition of pyrogallol auto-oxidation (MARKLUND; MARKLUND, 1974), and CAT activity by the decomposition of H_2O_2 (AEBI, 1984; MACHADO et al., 2022). Glutathione cycle activity was assessed using a commercial kit (Invitrogen) (Invitrogen (ThermoFisher Scientific), 2017). Lipid peroxidation was measured by MDA levels using the TBARS assay (BUEGE; AUST, 1978; MACHADO et al., 2022). Protein content was determined by the Bradford method (BRADFORD, 1976). Reagents were from Sigma-Aldrich or ThermoFisher Scientific. Absorbance was read using a Beckman DU 640 spectrophotometer or VICTOR™ X3 plate reader

2.6 STATISTICAL ANALYSIS

Statistical analysis was performed using GraphPad Prism software (version 8.02). The normality of data distribution was assessed using the Kolmogorov-Smirnov test. Depending on the experimental design, either one-way ANOVA followed by Tukey's post hoc test (for biochemical assays) or one-sample t-tests (for behavioral data) were employed. The one-sample t-test evaluated whether the discrimination index significantly differed from 50%, reflecting novel object preference (DE PAULA et al., 2021). A significance level of $p < 0.05$ was adopted for all analyses. Data are presented as mean ± standard error of the mean (SEM).

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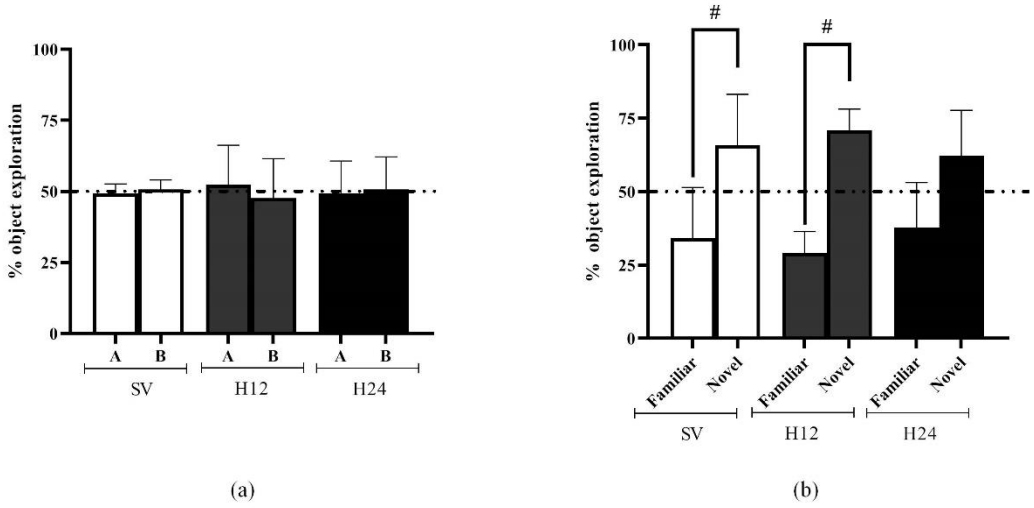
3 RESULTS

3.1 TWENTY-FOUR HOURS OF HYPEROXIA IMPAIRS MEMORY IN MICE

Following exposure to hyperoxia, all animals underwent the training session. During this phase, none of the groups exhibited a significant deviation from the expected performance value of 50%, confirming no baseline preference for either object (Fig. 1a). (SV: t=0.8047, df=15, *p*= 0.4335; H12: t=0.4871, df=7, *p*= 0.6411; H24: t=0.1821, df=7, *p*= 0.8607). In the test session, mice exposed to 12 hours of hyperoxia (H12) demonstrated intact recognition memory, spending significantly more time exploring the novel object. In contrast, animals exposed to 24 hours of hyperoxia (H24) explored both objects equally, suggesting impaired recognition memory (Fig. 1b). (SV: t=3.665, df=15, p= 0.0023; H12: t=8.140, df=7, p<0.0001; H24: t=2.254, df=7, p=0.0588).

Figure 1

Novel object recognition test



Cognitive performance between groups was accessed by NOR. a) Training session. All animals explored both objects equally. SV: 49.33% ± 0.8338 and 50.67% ± 0.8338; H12: 52.39% ± 4,898 and 47.61% ± 4.898; H24: 49.26% ± 4.050 and 50.74% ± 4.050 for objects A and B, respectively. b) Test session. The graph shows that only mice that were exposed to 24 h of hyperoxia had cognitive impairments because they did not have preference for exploring the new object. SV: 34.15% ± 4.327 and 65.86% ± 4.327. H12: 29.12% ± 2.565 and 70.88% ± 2.565; H24: 47. 33 ± 4.902 and 52. 67 ± 4.902 for familiar and novel objects,

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respectively. Data are presented and mean ± SEM; # compared to the hypothetical value of 50% between the percentage of old and new object exploration. $p < 0.05$).

3.2 HYPEROXIA ALTERS ANTIOXIDANT ENZYME ACTIVITY AND INDUCES LIPID PEROXIDATION IN THE HIPPOCAMPUS

Exposure to hyperoxia has induced significant changes in the hippocampal redox profile of mice. After 12 h of exposure, the was a marked increase in SOD activity compared to control (Fig. 2a). However, prolonged exposure to 24 h of 100% oxygen resulted in a substantial reduction in SOD activity. Catalase activity remained unchanged at both time points when compared to the control group (Fig. 2b), indicating that this enzyme was not responsive to hyperoxic stress under the tested conditions. GSH levels showed no alterations after 12 h of hyperoxia but were significantly elevated after 24 h of exposure (Fig. 2c), suggesting a compensatory antioxidant response. Consistent with the altered redox state, lipid peroxidation levels were elevated in both time points, as measured by TBARS (Fig. 2d) Mice exposed to 12 hours of hyperoxia exhibited moderately elevated TBARS levels, while a more pronounced increase was observed after 24 hours (Fig. 2d).

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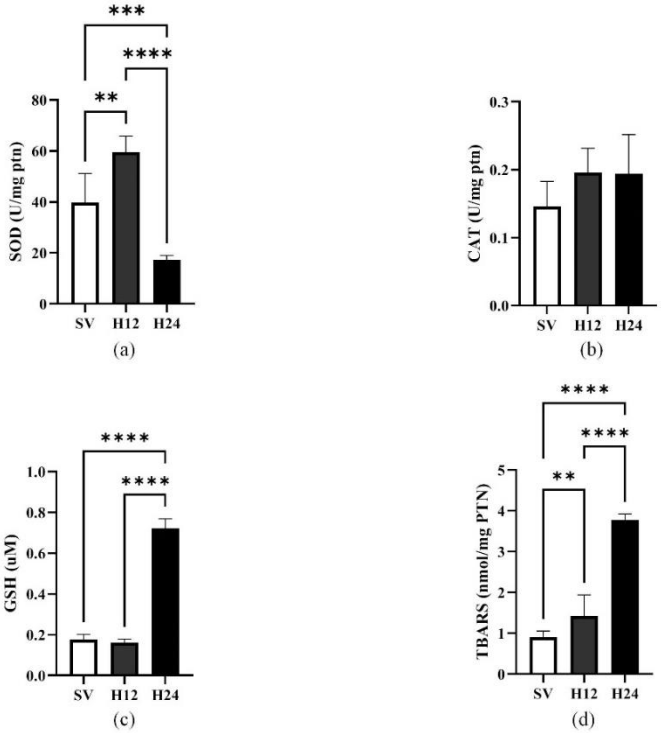
Figure 2

Activity of antioxidant defense enzymes and MDA levels



(a) OD activity; SV: 39.73 ± 3.060 U/mg PTN; H12: 59.63 ± 6.183 U/mg PTN; H24: 17.26 ± 0,6318 U/mg PTN (**= $p < 0.01$; ***= $p < 0,001$; ****= $p < 0.0001$). b) CAT activity; SV: 0.1459 ± 0.009236 U/mg PTN; H12: 0.1962 ± 0.0353 U/mg PTN; H24: 0.1942 ± 0.02028 U/mg PTN. c) GSH levels; SV: 0.1766 ± 0.006304 GSH (µM) H12: 0.1615 ± 0.006083 GSH (µM); H24: 0.7210 ± 0,04766 GSH (µM). (****= $p < 0.0001$). d) TBARS levels; SV: 0.9071 ± 0.03764 nmol/mg of total protein (PTN); H12: 1.423 ± 0.1947 nmol/mg PTN; H24: 3.781 ± 0.1410 nmol/mg PTN. (**= $p < 0.01$; ****= $p < 0.0001$). Data are presented and mean + SEM.

4 DISCUSSION

In this study, we demonstrated that 24 h, but not 12 h exposure to hyperoxia, impairs recognition memory in mice, as assessed by the NOR test. This cognitive deficit coincided with a substantial reduction in SOD activity, a pronounced increase in GSH levels and elevated lipid peroxidation, indicating redox imbalance and oxidative damage in the hippocampus.

Although the brain represents only a small fraction of total body mass but exhibits a high rate of oxidative metabolism driven by neuronal activity (SHIN et al., 2007). Exposure to hyperoxia, characterized by elevated levels of inspired oxygen, enhances the production of reactive oxygen species. This increase in oxidative stress could lead to neuronal damage and disrupt critical antioxidant enzymes, which may be linked to cognitive impairments (YUSA et al., 1987).

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The acquisition, consolidation, and retrieval of declarative memories are crucial functions of the hippocampus (HUANG et al., 2015). In this study, 12 h of hyperoxia did not significantly affect memory performance in mice, although elevated levels of malondialdehyde (MDA) were detected in the hippocampus. Prolonging hyperoxia to 24 h resulted in a marked increase in MDA levels. Additionally, mice exposed to 24 h of hyperoxia showed impaired recognition of novel objects in the object recognition test. Elevated MDA levels are typically associated with lipid peroxidation and neuronal dysfunction, which aligns with our findings of compromised memory function (ALVA et al., 2023).

To further investigate the oxidative outcomes of hyperoxia, we evaluated the endogenous antioxidant system by measuring the enzymatic activity of superoxide dismutase (SOD), catalase (CAT), and levels of glutathione (GSH). SOD is a key enzyme that initially responds to counteract superoxide anions, which are primarily generated during hyperoxia (HALLIWELL; GUTTERIDGE, 2015; IGHODARO; AKINLOYE, 2018). Our results indicated an increase in SOD activity in the hippocampus after 12 h of hyperoxia. However, after 24 hours of hyperoxia, SOD activity decreased. This reduction in SOD activity may be attributed to prolonged hyperoxia generating elevated levels of superoxide anions, which could overwhelm the antioxidant defense mechanisms and lead to enzymatic degradation.

In the brain, hydroperoxide formation is typically counteracted by glutathione peroxidase (GPx), which uses glutathione (GSH) as an electron donor (BARBOSA et al., 2010; MACHADO et al., 2022; PEI et al., 2023). GSH can also reduce organic hydroperoxides, distinguishing GPx from catalase (CAT) (HALLIWELL; GUTTERIDGE, 2015; PEI et al., 2023). In response to redox challenges, an increase in GPx activity can be seen as an adaptive response aimed at restoring the hippocampal enzymatic antioxidant defense system and mitigating lipid peroxidation. This adaptation is particularly evident after 24 h of hyperoxia exposure, where GPx activity is significantly elevated. This shift in enzymatic activity, characterized by a decrease in SOD and an increase in GPx, reflects the body's effort to maintain redox balance (KÖRPINAR; UZUN, 2019; MACHADO et al., 2022). However, sustained oxidative stress from 24 hours of hyperoxia ultimately proves detrimental, leading to impaired cognitive functions.

Oxygen supplementation, although a well-established clinical practice, has seen increased application in managing respiratory complications associated with COVID-19. While this study does not directly address COVID-19, it provides an experimental murine model to examine the effects of hyperoxia on the brain. Our results indicate even a few hours

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of elevated oxygen levels can lead to potential damage to cell membranes and significant alterations in the activity of antioxidant enzymes in the hippocampus. While oxygen therapy is crucial in many clinical scenarios, increasing the partial pressure of oxygen (PaO_2) above 300 mmHg warrants careful consideration due to potential risks to brain health.

5 CONCLUSION

Our findings show that prolonged hyperoxia induces hippocampal oxidative damage and memory impairment. This response appears biphasic, with an initial antioxidant upregulation followed by redox imbalance and oxidative stress after sustained exposure.

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REFERENCES

Aebi, H. (1984). Catalase in vitro. In S. P. Colowick & N. O. Kaplan (Eds.), Methods in Enzymology (Vol. 105, pp. 121–126). Academic Press. https://doi.org/10.1016/S0076-6879(84)05016-3

Alva, R., et al. (2023). Oxygen toxicity: Cellular mechanisms in normobaric hyperoxia. Cell Biology and Toxicology, 39(1), 111–143. https://doi.org/10.1007/s10565-022-09689-4

Barbosa, K. B. F., et al. (2010). Oxidative stress: Concept, implications and modulating factors. Revista de Nutrição, 23(4), 629–643. https://doi.org/10.1590/S1415-52732010000400013

Bezerra, F. S., et al. (2019). Exogenous surfactant prevents hyperoxia-induced lung injury in adult mice. Intensive Care Medicine Experimental, 7(1), 53. https://doi.org/10.1186/s40635-019-0261-6

Revista ARACÊ
ISSN: 2358-2472

Bradford, M. M. (1976). A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. Analytical Biochemistry, 72, 248–254. https://doi.org/10.1016/0003-2697(76)90527-3

Brehmer, F., et al. (2012). Interaction of inflammation and hyperoxia in a rat model of neonatal white matter damage. PLoS One, 7(11). https://doi.org/10.1371/journal.pone.0049023

Buege, J. A., & Aust, S. D. (1978). Microsomal lipid peroxidation. In S. Fleischer & L. Packer (Eds.), Methods in Enzymology (Vol. 52, pp. 302–310). Academic Press. https://doi.org/10.1016/S0076-6879(78)52032-6

De Paula, G. C., et al. (2021). Hippocampal function is impaired by a short-term high-fat diet in mice: Increased blood–brain barrier permeability and neuroinflammation as triggering events. Frontiers in Neuroscience, 15, 748632. https://doi.org/10.3389/fnins.2021.748632

Halliwell, B., & Gutteridge, J. M. C. (2015). Free radicals in biology and medicine (5th ed.). Oxford University Press.

Huang, R. R., et al. (2015). Chronic restraint stress promotes learning and memory impairment due to enhanced neuronal endoplasmic reticulum stress in the frontal cortex and hippocampus in male mice. International Journal of Molecular Medicine, 35(2), 553–559. https://doi.org/10.3892/ijmm.2014.2040

Ighodaro, O. M., & Akinloye, O. A. (2018). First line defence antioxidants—Superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GPX): Their fundamental role in the entire antioxidant defence grid. Alexandria Journal of Medicine, 54(4), 287–293. https://doi.org/10.1016/j.ajme.2017.09.001

Invitrogen (ThermoFisher Scientific). (2017). Glutathione colorimetric detection kit product information sheet. https://www.thermofisher.com/us/en/home/global/terms-and-conditions.html

Ishida, Y., et al. (2021). ORi™: A new indicator of oxygenation. Journal of Anesthesia, 35(5), 734–740. https://doi.org/10.1007/s00540-021-02936-7

Körpinar, S., & Uzun, H. (2019). The effects of hyperbaric oxygen at different pressures on oxidative stress and antioxidant status in rats. Medicina, 55(5), 215. https://doi.org/10.3390/medicina55050215

Machado, R. S., et al. (2022). Hyperoxia by short-term promotes oxidative damage and mitochondrial dysfunction in rat brain. Respiratory Physiology & Neurobiology, 306, 103929. https://doi.org/10.1016/j.resp.2022.103929

Marklund, S., & Marklund, G. (1974). Involvement of the superoxide anion radical in the autoxidation of pyrogallol and a convenient assay for superoxide dismutase. European Journal of Biochemistry, 47(3), 469–474. https://doi.org/10.1111/j.1432-1033.1974.tb03714.x

Revista ARACÊ
ISSN: 2358-2472

Nagato, A. C., et al. (2012). Time course of inflammation, oxidative stress and tissue damage induced by hyperoxia in mouse lungs. International Journal of Experimental Pathology, 93(4), 269–278. https://doi.org/10.1111/j.1365-2613.2012.00822.x

Ni, Y. N., et al. (2019). The effect of hyperoxia on mortality in critically ill patients: A systematic review and meta-analysis. BMC Pulmonary Medicine, 19(1), 53. https://doi.org/10.1186/s12890-019-0812-9

Pei, J., et al. (2023). Research progress of glutathione peroxidase family (GPX) in redoxidation. Frontiers in Pharmacology, 14, 1165945. https://doi.org/10.3389/fphar.2023.1165945

Perrone, S., Laschi, E., & Buonocore, G. (2020). Oxidative stress biomarkers in the perinatal period: Diagnostic and prognostic value. Seminars in Fetal and Neonatal Medicine, 25(6), 101087. https://doi.org/10.1016/j.siny.2020.101087

Schneider, E., et al. (2021). Larger capacity for unconscious versus conscious episodic memory. Current Biology, 31(16), 3551–3563.e9. https://doi.org/10.1016/j.cub.2021.06.038

Shin, H. K., et al. (2007). Normobaric hyperoxia improves cerebral blood flow and oxygenation, and inhibits peri-infarct depolarizations in experimental focal ischaemia. Brain, 130(6), 1631–1642. https://doi.org/10.1093/brain/awm092

Shrestha, P., & Klann, E. (2016). Lost memories found. Nature, 531(7595), 450–451. https://doi.org/10.1038/531450a

Yusa, T., et al. (1987). Hyperoxia increases H2O2 production by brain in vivo. Journal of Applied Physiology, 63(1), 353–358. https://doi.org/10.1152/jappl.1987.63.1.353