行政院國家科學委員會專題研究計畫　成果報告

高壓氧對糖尿病鼠血液流變之影響

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一、中文摘要

本實驗主要目的是瞭解當糖尿病老鼠作高壓氧治療，糖尿病老鼠之血液流變參數的變化。本研究為 placebo-controlled 之動物實驗。首先先將 30 隻老鼠施打 strepozocin 使其引發糖尿病，並分為兩組，其中一組接受高壓氧治療（7 天，2 小時/每天），另一組則無。最後，經由心臟取血的手術過程取得老鼠全血做血液流變學參數的測試。所有實驗組與對照組糖尿病鼠之血液學和血液流變學的數據都經過 *t*-tests 分析。

實驗結果證實，高壓氧組的糖尿病鼠紅血球有較高的脂質過氧化（HBO_2：9.03±0.39；CON：5.46±0.27，P＜0.01），高壓氧組的糖尿病鼠紅血球的變形阻力係數 β 也較高（HBO_2：19.18±1.29，CON：8.92±0.49，P＜0.01）。此外，在不同剪應力(或剪切速率)下的全血黏度方面，實驗結果也顯示高壓氧組糖尿病鼠的全血黏度值都較高（HBO_2：20.18±1.12，CON：13.03±0.94，$\gamma=5s^{-1}$，P＜0.01；HBO_2：8.36±0.34，CON：6.31±0.16，$\gamma=150s^{-1}$，P＜0.01；HBO_2：6.43±0.19，CON：5.13±0.19，$\gamma=400s^{-1}$，P＜0.01）。至於血液中氧氣供應指數，高壓組糖尿病鼠則明顯較對照組糖尿病鼠來得低（HBO_2：2.36±0.11，CON：3.33±0.27，$\gamma=5s^{-1}$，P＜0.01）。總而言之，本實驗證實高壓氧療法對於糖尿病鼠的血液流變參數會有明顯之改變(異常)。

關鍵字：高壓氧，糖尿病鼠，全血黏度，全血黏彈性，紅血球變形度

Abstract

Hyperbaric oxygen therapy (HBT), a therapy performed in an environment under 100% oxygen exposure of more than 1 atm (1 atm = 101.3247 kPa) environment, has been practiced for more than 20 years. Although the basic mechanisms of action of HBO was not clear, HBT has been widely practiced in treating wounds. In diabetic patients, HBT was found to be effective in healing ulcers and lesions on the foot. However, HBT is not an ideal cure for all kinds of medical syndromes. In the past study, HBO increase of oxidative myocardial stress, increasing pulmonary capillary permeability, and causing pulmonary oxygen toxicity.

On the other hand, from a haemorheological point of view, in the rats model ,HBO decreases erythrocyte deformability and produced a significant increase in fibrinogen concentration of plasma and blood viscosity . To be specific, in order to learn more about the potential risks and benefits which HBT can cause with diabetes, an animal mold was used in our research to study its effects on haemorheological parameters, including erythrocyte deformability, lipid peroxidation of erythrocyte membrane, blood viscosity and oxygen delivery index etc., as compared to those measured in non-exposed diabetic rats. These results may provide a useful reference for doctors for use in clinical treatment.

二、緣由與目的

高壓氧治療（Hyperbaric oxygen therapy,HBT）已經實行超過二十年，此種治療環境是處於高於 1 大氣壓、並以 100%氧氣濃度的環境之下治療。雖然 HBO 的作用機制目前並不十分明確，但是高壓氧治療目前卻已經廣泛應用於傷口處理的範疇。尤其在糖尿病病人中，高壓氧治療對於潰瘍癒合以及腳部組織機能損傷，臨床上治療都有良好的效果。不過，高壓氧治療並非對於所有醫療症候群都是有明顯成效的，以過去的研究為例，氧化心肌 HBO 壓力的增加，反而提高了肺部微血管的滲透性，因而造成肺部氧中毒。

就血液流變學的觀點來看，在老鼠的模型當中，HBO 降低了紅血球的變形度，以及造成血漿中纖維蛋白濃度與血液黏度提昇。為了進一步研究更多潛在的危險和高壓氧治療對於糖尿病患的好處，我們試著了解高壓氧對糖尿病鼠之血液流變參數之影響，這些參數包含了「紅血球變形度」、「紅血球膜的脂質氧化」、「血液黏度」、「氧氣運輸指數」…等等；期待以上這些研究結果能夠提供給醫師在臨床治療上一些有用的參考資料。

三、結果

由實驗結果知，經高壓氧治療的老鼠的血液之指標值均與未經高壓氧治療的老鼠有差異。

1. Hct 平均值：高壓氧老鼠 Hct 47.5%，未經高壓氧治療的老鼠 Hct 43.6%，$P<0.01$
2. 血漿中纖維蛋白原平均值：高壓氧老鼠 259.8mg/l，未經高壓氧治療的老鼠 187.4 mg/l
3. 血液黏度：高壓氧老鼠血液黏度明顯比未經高壓氧治療的老鼠高，分別列出高中低剪應力所測得的血液黏度值

   高剪應力 $400s^{-1}$ 時，高壓氧老鼠血液黏度為 6.01cp

   高剪應力 $400s^{-1}$ 時，未經高壓氧治療的老鼠血液黏度為 5.13cp

   中剪應力 $150\ s^{-1}$ 時，高壓氧老鼠血液黏度為 7.19cp

   中剪應力 $150\ s^{-1}$ 時，未經高壓氧治療的老鼠血液黏度為 6.31cp

   低剪應力 $5\ s^{-1}$ 時，高壓氧老鼠血液黏度為 15.32cp

   低剪應力 $5\ s^{-1}$ 時，未經高壓氧治療的老鼠血液黏度為 13.03cp
4. 脂質過氧化：紅血球膜脂質過氧化程度中，高壓氧老鼠脂質膜過氧化程度比未經高壓氧治療的老鼠高，高壓氧老鼠 9.03×10^{10}mol/cell，未經高壓氧治療的老鼠 5.46×10^{10}mol/cell
5. 紅血球變形度：高壓氧老鼠紅血球變形度 0.89，未經高壓氧治療的老鼠 0.86
6. 氧氣運輸指數：高壓氧老鼠氧氣運輸指數 2.36，氧氣運輸指數氧氣運輸指數 3.33

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