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Impaired oxygen utilisation in hydrocephalus: a non-invasive study

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Imaging techniques such as ultrasound scanning, MRI scanning and CT scanning, which are currently used in the diagnosis and management of hydrocephalus do not provide information regarding changes observed in cerebral haemodynamics and metabolism in hydrocephalus. Near infrared spectroscopy (NIRS) is a relatively new non-invasive technique, which can fulfil this need. Near infrared spectroscopy can be used to make continuous measurements of oxyhameoglobin (O_2Hb), deoxyhaemoglobin (HHb) and oxidised cytochrome c oxidase (Caa_3), which is the terminal enzyme of the mitochondrial respiratory chain. Hence, information regarding changes in haemoglobin oxygen supply and oxygen utilisation in the cell is provided. The summation of O_2Hb and HHb represents changes in total haemoglobin (tHb) and this provides information regarding perfusion status. The difference between O_2Hb and HHb is the haemoglobin oxygenation index (HbD) and this reflects net changes in oxygenation. The aim of this study was to determine if the non-invasive technique of NIRS could detect differences in cerebral haemodynamics and oxygen utilisation between hydrocephalic and normal rats from the HTx rat model. Rats were restrained and placed onto an adjustable platform in a supine position. Baseline was established for 5–10 mins following which an increase in intracranial pressure was induced via a 45° head down tilt for 5 mins. After removal of the tilt and return of the rat to the supine position, NIRS monitoring was continued for a further 5–10 mins. A total of 24 normal and 12 hydrocephalic rats were studied. It was found that upon tilting a significant difference in change of HbD concentration was observed between the normal (-2.67 ± 1.49 μM/cm) and hydrocephalic (7.21 ± 2.89 μM/cm) rats ($P < 0.005$). HbD was greater in the hydrocephalic than in the control group (O_2Hb > HHb) and this is suggestive of impaired oxygen utilisation in hydrocephalic rats.

In a preliminary study we investigated the effect of sodium pento-barbitone administration, a known inhibitor of complex I of the respiratory chain. We measured a significant difference in the level of cytochrome c oxidase in hydrocephalic (-2.73 ± 1.07 μM/cm, $n = 4$) compared to normal (-6.32 ± 0.51 μM/cm, $n = 5$) rats. These preliminary studies are encouraging and suggest that NIRS could be valuable in providing information that is vital for successful management of hydrocephalus.