Venous hydrodynamics and multiple sclerosis

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Introduction: Conventional wisdom suggests that multiple sclerosis (MS) is an inflammatory autoimmune disorder, arising from interplay between, as yet, unidentified environmental factors and susceptible genes [1]. However, there is increasing evidence that the condition may have a vascular component, with many researchers [2-4] implicating the venous system in its aetiology. Recently it has been observed that many patients with MS exhibit stenosis of the extracranial venous pathways from the brain [5], with the result that there is extensive collateral rerouting of the blood flow back to the heart. Despite this, the role that the venous system plays in the pathophysiology of MS remains unclear - primarily due to the fact that the hydrodynamic behavior of the cerebral venous system is poorly understood.

Materials & Methods: This paper uses hydrodynamic analysis to interpret the findings of other researchers regarding the pathophysiology of MS. In particular, analysis is undertaken of the impact that extracranial venous stenosis has on blood flow in the cortical and periventricular veins. The impact of stenosis on cerebrospinal fluid (CSF) dynamics is also discussed.

Results: Hydrodynamic analysis suggests that stenosis of the extracranial venous pathways is likely to have a profound impact on the fluid dynamics of the brain, with the behavior of both the cerebral venous and CSF systems affected. Increasing the hydraulic resistance of the extracranial venous pathways will tend to increase pressure in the venous sinuses; with result that flow through both the deep and superficial venous systems may be impaired. CSF efflux from the subarachnoid space to the superior sagittal sinus (SSS) is also likely to be impaired.

Discussion & Conclusion: Although collateral rerouting of blood flow may occur, stenosis of the extracranial venous pathways will inevitably increase the hydraulic resistance of the cerebral vascular circuit. Increasing the system resistance will have a dual effect; firstly, it will tend to reduce cerebral blood flow (CBF), and secondly, it

will raise the pressure in the venous sinuses [6]. Evidence supporting the former conclusion comes from several studies [7-9], all of which observed lower CBF in the normally appearing white matter of MS patients compared with healthy controls, particularly in the periventricular region where MS lesions typically form. While no published data exists regarding blood pressure in the venous sinuses of MS patients, indirect evidence of hypertension in these vessels comes from two studies [10, 11]. In the first of these, Zamboni *et al* observed that following angioplasty to open up stenotic vessels, the venous pressure in MS patients dropped by approx. 2.2 mm Hg [10]. In the second study [11], Zamboni *et al* found that the bulk flow of the CSF in MS patients was greatly reduced compared with healthy controls; something that is indicative of raised blood pressure in the SSS.

The pressure gradient through the cerebral blood vessels is such that any increase in pressure in the venous sinuses, will have greatest impact on the cerebral veins. This is particularly the case with the periventricular veins, which are thin walled vessels that normally experience very low pressures. By comparison, impact on the cortical veins is more complex. Because these vessels possess sphincters/starling resistors [12], it means that blood flow through the cortical veins is influenced by the dynamics of the CSF as well as the pressure in the SSS. Consequently, any change in the pressure and pulse of the CSF in the subarachnoid space will have a profound effect on blood flow in these vessels and this may explain, in part, why MS lesions are frequently observed adjacent to veins in the cortical region [13]. If hypertension is present in the sinuses, then this would lower the pressure drop through the cerebral veins, resulting in reduced blood flow through these vessels – a reduction that, if large enough, could induce hypoxic stress in the endothelia. There is increasing evidence to suggest that a hypoxia-like metabolic injury is a pathogenetic component in the formation of MS lesions [14].

References:

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