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Antioxidant Enzymes and Related Trace Elements in Aging Brain Capillaries and Choroid Plexus

Ivan Tayarani, *Isabelle Cloëz, *Michel Clément, and *Jean-Marie Bourre

*Département de Biotechnologie, Institut Pasteur, and *INSERM U26, Hôpital Fernand Widal, Paris, France*

Abstract: The activities of superoxide dismutase (SOD), glutathione peroxidase, glutathione reductase, and catalase were measured in isolated brain capillaries, choroid plexus, cerebrum, and cerebellum from rats of 2, 6, 12, and 24 months. The contents of copper, zinc, and manganese were determined in capillaries, cerebrum, and cerebellum, and the profile of fatty acids was studied in brain capillaries. In brain capillaries, the activities of glutathione peroxidase and glutathione reductase did not change with age. The activities of the two enzymes increased in cerebrum and cerebellum. In choroid plexus, glutathione peroxidase activity increased, but glutathione reductase activity remained unchanged. Catalase activity in brain capillaries declined, whereas in choroid plexus, cerebrum, and cerebellum, it did not change. The activities of the three enzymes were significantly higher in brain capillaries and choroid plexus than in cerebrum and cerebellum. SOD activity increased in the four tissues. Copper content in the capillaries increased initially and then levelled off, whereas it continued to increase in cerebrum and cerebellum. Zinc increased in brain capillaries, but did not vary in cerebrum and cerebellum. Manganese content remained constant in all tissues studied. The percent of saturated fatty acids in brain capillaries did not change with age, whereas those of mono- and polyunsaturated fatty acids increased and decreased, respectively. The possibility that a deficiency of enzymes protective against free radicals causes blood–brain barrier and blood–cerebrospinal fluid barrier degeneration is ruled out. **Key Words:** Blood–brain barrier—Choroid plexus—Antioxidant enzymes—Trace elements—Polyunsaturated fatty acids—Aging. **Tayarani I. et al.** Antioxidant enzymes and related trace elements in aging brain capillaries and choroid plexus. *J. Neurochem.* **53**, 817–824 (1989).

The blood–brain barrier (BBB) and the blood–cerebrospinal fluid barrier (blood–CSF barrier), composed, respectively, of the cerebral capillary endothelial cells and the choroid plexus, provide homeostasis in the CNS by the presence of energy-dependent transport mechanisms (Bradbury, 1979). Hypoxic events in the brain may alter these transport processes and lead to significant changes in metabolic and enzymatic activities in this tissue (Harik et al., 1982; Ádám et al., 1987). The brain continuously requires oxygen for its normal functions. Nevertheless, oxygen metabolism generates reactive species, which, if not eliminated, can induce various forms of tissue pathology having endothelial damage as the common denominator (Kontos, 1985; Gryglewski et al., 1986; Oleson, 1987).

Another source of oxygen free radicals is the activity of xanthine oxidase, which is reported to be present in rat brain capillaries (Betz, 1985). It has been shown that xanthine oxidase induces phospholipid degradation (Chan et al., 1982) and that oxygen free radicals render the capillaries highly permeable to proteins and may alter intracellular water, sodium, and potassium content (Del Maestro et al., 1981; Chan et al., 1984).

The brain is susceptible to lipid peroxidation owing to its high content of polyunsaturated fatty acids and to its high aerobic metabolism. Several protective systems exist in the brain, however, that prevent the accumulation of oxygen-derived free radicals: superoxide dismutase (SOD) and catalase, and the glutathione scavenging system. The latter consists of glutathione, glutathione peroxidase, and glutathione reductase.

The activities of various enzymes in the brain have been shown to decrease with age (McGeer et al., 1971; Reiss and Gershon, 1976). To our knowledge, the levels of enzymes that protect against peroxides in aging brain capillaries and choroid plexus have not yet been reported. Free radical reactions and peroxidation of membrane lipids may cause age-associated pathological changes (Harman, 1980). Determining whether aging affects the enzymes that protect brain capillaries and

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Address correspondence and reprint requests to Dr. I. Tayarani at his present address: Département de Biotechnologie, Technologie Cellulaire, Institut Pasteur, 75015 Paris, France.

Abbreviations used: BBB, blood–brain barrier; blood–CSF barrier, blood–cerebrospinal fluid barrier; GSH, reduced glutathione; SOD, superoxide dismutase.