Microcirculation and aging

Vladimir Cerny

Dept. of Anesthesiology and Intensive Care, Faculty of Medicine in Hradec Kralove, University Hospital Hradec Kralove, Hradec Kralove, Czech Republic
email: cernyvla@fnhk.cz

People over 75 years of age represent nearly half of all general hospital admittances and the majority of unscheduled early re-hospitalization. The PAQUID Bordeaux Study projects that this age segment will increase from 7.7% of population in 2003 to 9.6% in 2010 and 18% in 2050. Between 2008 and 2060 the population of the EU-27 aged 65 and over is projected to increase by 66.9 million and the "very old" (80+) will be the fastest growing segment of the population. Two important principles must be kept in mind when discussing the physiology of aging. First, aging is associated with a progressive loss of functional reserve in all organ systems. Second, the extent and onset of these changes are highly variable from person to person and any general statement regarding these changes (i.e. in microcirculation) may not be applicable in particular patient. In the vast majority of older patients, physiologic compensation for age-related changes is adequate, but the resultant limitation in physiologic reserve may become evident only during times of physiologic stress, including exercise, illness, and the perioperative period. Microcirculation regulates tissue blood flow and local tissue oxygen diffusion, and has a key role in the development of numerous diseases and dysfunctions. Age leads to various changes at all organ and tissues and arterial and microcirculation aging has become the most common and important issue with which modern physicians must deal. It affects not only great vessels, but also the small vessel disease, (namely in brain and kidney, which is the principal cause of dementia and renal failure in older persons).

Age related changes in the microcirculation – what is the evidence?

Brain
- Increased arterial stiffness and microvascular damage in brain vessels (Triantafyllidi, 2009)
- Aging-related cerebral microvascular degeneration is an important cause of essential hypertension (Qin, 2008)
- Age-related microvascular degeneration in the human white matter, but the vascular density did not correlate with the age. (Farkas, 2006)
- Aging is associated with increased collagen type IV accumulation in the basal lamina of human cerebral microvessels. Age-related changes of the cerebral microvessels in sections of human putamen for the first time. Due to the accumulation of collagen, microvessels thicken and show a reduction in their lumen. Besides this, the number of vessels decreases. These findings might represent a precondition for the development of vascular cognitive impairment. (Uspenskaia, 2004)
- Reduced vasomotor reactivity in cerebral microangiopathy in aged patients (Terborg, 2000)
- Aging of the cerebral microcirculation results in significant alteration in the blood-brain barrier. (Shah, 1997)
- Aging is associated with increased lipid peroxidation byproducts in cerebral microvessels along with a transient decrease in their antioxidative capacity. (Mooradian, 1995)
Age-related changes in the activity of ATPases in cerebral microvessels are present. These changes may contribute to the altered blood-brain barrier functions found in aged rats. (Mooradian, 1994)

Aging is associated with significant quantitative changes in protein composition of cerebral microvessels. The increased concentration of conjugated dienes in cerebral microvessels of aged rats is indicative of ongoing free radical damage in these microvessels which may contribute to the age-related changes in BBB function. (Mooradian, 1992)

Age-related decreases in the synthesis of vascular proteins may contribute, in part, to some of the changes in the mechanical and functional properties of blood vessels during aging. (Gozes, 1981)

Kidney

Renal microvascular disease is the crucial determinant of renal fibrosis in aged people. (Futrakul, 2008)

NO synthesis blockade has a greater effect on renal hemodynamics in aging rats and implies that NO may play a progressively more important role in controlling renal function with advancing age. (Reckelhoff, 1993)

Comparisons of laser-Doppler flow signals obtained from the renal papilla of young and adult animals indicated that papillary blood flow was approximately 2-fold greater in the adult rats than in the young animals. (Roman, 1986)

Liver

Morphological changes in the hepatic sinusoid with old age include thickening and defenestration of the liver sinusoidal endothelial cell, sporadic deposition of collagen and basal lamina in the extracellular space of Disse, and increased numbers of fat engorged, nonactivated stellate cells. In addition, there is endothelial up-regulation of von Willebrand factor and ICAM-1 with reduced expression of caveolin-1. These changes have been termed age-related pseudocapillarization. (Le Couteur, 2008)

Age-related changes in the architecture of the liver sinusoidal network, which may influence hepatic function and reflect broader aging changes in the microcirculation. However, sinusoidal dimensions and hepatic vascular dispersion are not markedly influenced by old age. (Warren, 2008)

14% reduction in the numbers of perfused sinusoids between 0.8 and 27 month mice associated with 35% reduction in sinusoidal blood flow. There is also fivefold increase in leukocyte adhesion in 27 month mice, up-regulated expression of ICAM-1, and increases in intrahepatic macrophages. Sinusoidal diameter decreased 6-10%. (Ito, 2007)

Periportal and pericentral sinusoidal velocities of weanling (young) were approximately 30 and 25% faster, respectively, than those in adults. (Drugas, 1993)

Splanchnic/mesenteric microcirculation

Age-related decrease in perimicrovascular protein in exteriorized mesenteric windows in rats (Barber, 1995)

Summary of most important age-related (micro)vascular changes:

- Increase in medial and intimal thickness
- Increase in endothelial variant cells
- Change in vascular wall matrix
- Decrease in beta receptor content
- Decrease of beta receptor responsiveness
- Decrease in NO production
- Decrease of vasodilatation response
- Decrease of functional capillary density

Age-related changes in microvascular structure and function may be associated with end-organ dysfunction and may contribute to the increased susceptibility of the microvascular injury caused by anesthesia and surgery in old patients.

Suggested readings: