Cognitive changes in aging – the implications for us as anaesthetists

Aging

Aging is a universal and progressive physiological phenomenon clinically characterised by degenerative changes in:

• The structure of organs and tissue
• The functional capacity of organs and tissues

Life span is an idealised, species-specific biologic parameter that quantifies maximum attainable age under optimal environmental conditions, whereas life expectancy describes an empirical estimate of typical longevity under prevailing or predicted circumstances. Advances in medical science and health care have changed this considerably over the last few decades.

The elderly in anaesthetic terms is someone > 65 years.

Functional reserve is the difference between maximum and basal levels of function. It provides the “safety margin” to meet the additional demands imposed by trauma or disease, or by surgery, healing and convalescence. Currently we are able to quantify cardiopulmonary reserve, but not renal, hepatic or nervous system reserve.

Decrement of maximum function that occur during the middle adult years are relatively subtle, and often suddenly become more apparent during the seventh decade of life and beyond, and particularly under times of physiological “stress”, such as during exercise, illness and the perioperative period. In addition, the extent and onset are very variable from person to person.

Mechanisms of aging

The precise mechanisms that control the aging process and determine life span are unknown. Theories of aging fall into two major categories:

• Stochastic, which are dependent on time and probability and due to random errors of protein synthesis
• Non-stochastic concepts, which involve a common theme of “biological clock” for each species. This is reliant on neuroendocrine or immune mechanisms.

However, on a cellular level, the mechanism of aging is probably a combination of stochastic and non-stochastic theories. It is thought to be due to life-long oxidative stress. This leads to a decline in the enzymatic machinery required for full bioenergetic capacity and damage to the mitochondrial DNA (mtDNA) needed for synthesis of the enzymes that protect cells from metabolic by-products by scavenging reactive oxygen species (ROS) from the cytosol of aging cells. In addition, the whole process of apoptosis needs to be taken into account when looking at the mechanisms of aging.

Physiology of aging – cognitive changes

Healthy aging is associated with significant changes in the morphology, physiology and biochemistry of the brain in the following ways:

• Decreased brain size and weight: these changes begin in young adulthood, but accelerate after the age of 60 years, resulting ultimately in a 15% decrease in the ratio of brain/skull volume, and the ventricular volume triples.
• Age-associated decreases in neuronal size, loss of complexity of the dendritic tree, and a reduced number of synapses.
• Cerebral circulation physiology does not change, BUT global cerebral blood flow (CBF) is decreased (up to 10–20%), because there is less brain to perfuse. CMRO2 is also reduced as a consequence, but it is still tightly coupled with CBF.
• Cerebral autoregulation and responsiveness to CO2 and hypoxaemia are reasonably well preserved.
• Neurotransmitter systems are extensively affected by aging:
  1. Dopamine uptake sites, transporters, and levels are reduced.
  2. Cortical serotonergic, α2 and β1, and aminobutyric acid binding sites are reduced.
  3. Markers of central cholinergic activity also decrease. This is of particular significance because failure of cholinergic neurotransmission is a central feature of Alzheimer’s disease.
• There is reduced expression in the human brain of genes involved in learning and memory and neuronal survival. This begins at age 40!
• The capability to make new neurons is preserved, albeit reduced.

How does all of this affect brain function?

• Intellectual decline is not invariable, but is common.
• Reaction time and cognitive processing slow to such an extent that there is an inverse relationship between age and speed of motor performance, which becomes exaggerated with increasing task complexity.
• “Fluid” intelligence deteriorates. This is the ability to dynamically evaluate, accommodate, and respond to novel environmental events (like a resuscitation?).
• “Crystallised” intelligence (accumulated knowledge), such as
Vocabulary, maths and comprehension skills are well maintained until the seventh decade.

- Short-term memory dysfunction occurs in up to 30–50%.
  Much of this impairment is in “working” memory, which requires manipulation of information, as well as retention. Thus the ability to store recently processed information, as well as simultaneously acquiring new data is compromised.

Pathologic aging includes all of the changes that occur in the healthy aging brain, as well as a high incidence of dementia (10–15% in persons aged 65 to nearly 50% at age 85 years). If this occurs in an anaesthetist that person should be considered “impaired”, and the appropriate action taken.

The other important system that needs to be taken into account together with the brain and cognitive aging is the sensory/perceptual system. Aging of this system, which involves taste, smell, sight and hearing, provides the closest correlation between chronologic and biologic age, and has the potential of imposing serious handicaps on the elderly doctor, particularly the aging anaesthetist.

What about the aging/elderly anaesthetist?

The successful practice of anaesthesiology requires a high degree of knowledge and skill, as well as mental and physical stamina. Those who fail to maintain these standards are at risk of causing serious injury to their patients. Many other professions that place similar demands on their practitioners have been more aggressive about monitoring the health, well-being and competence of their aging practitioners, notably the airline industry. Commercial pilots are required to take regular examinations to demonstrate their continued good health and professional skills. This is in sharp contrast to our profession, particularly in South Africa, but also in many other countries.

Do anaesthesiologists have a similar life expectancy to the general population? Numerous studies have looked at this. In 1974 Bruce et al concluded that the overall death rate in anaesthesiologists is low, with no evidence of high mortality risk with respect to coronary artery disease. Death from suicide continues to be high in anaesthesiologists, particularly those of middle-age.

Is it an advantage to be an elderly anaesthetist? In a healthy elderly anaesthetist, experience, insight and wisdom are definite advantages, and often compensate for varying degrees of cognitive deterioration. Unfortunately, however, these advantages may well be outweighed by all the disadvantages, such as slow reaction time and cognitive processing, and short-term memory dysfunction. In addition, the deterioration in “fluid” intelligence is of grave concern, as this involves the ability to dynamically evaluate, accommodate and respond to novel environmental events, such as an anaesthetic crisis.

The sensory/perceptual deterioration is also of concern. Most elderly anaesthetists will be aware of visual disturbances, and will rectify this by means of spectacles or minor surgical procedures. Hearing impairment, however, may be far more troublesome, particularly as many people are not aware of their hearing impairment. Most individuals older than 40 years have some degree of hearing loss. The incidence in anaesthetists has been found to be higher, and Wallace et al (in 1994) found an 80% incidence of abnormal audiogram in anaesthetists older than 45 years! One of the alarming findings is that most hearing-impaired anaesthetists were unaware of their impairment. In addition, 39% of anaesthetists in the 65–74 years age group had one or more alarms below detectability threshold, particularly if there was a significant degree of background noise.

What about fatigue in the elderly anaesthetist? Fatigue is defined as “a subjective feeling of the need to sleep, an increased physiological drive to fall asleep and a state of decreased alertness”. The practice of anaesthesia, as we know, is subject to significant sleep disturbance, particularly if shift work is done. Where sleep loss is combined with circadian rhythm disturbance, the risk of fatigue occurring is high. Studies have shown that recovery from fatigue is delayed in individuals after the age of 45. Numerous studies have reported that half of the anaesthesia providers surveyed had made errors in medical judgment, which were attributed to fatigue. As the recovery from fatigue is delayed after the age of 45, the Association of Anaesthetists of Great Britain and Ireland (AAGBI) has recommended that any practising anaesthetist over the age of 55 years should have their working hours reviewed. The extrapolation here would be that perhaps they should not be doing night calls?

In summary, doctors are no exception to the aging process, which affects all organ systems. The brain and senses are not spared and changes that occur with aging may well impair one’s ability to practise one’s specialty, particularly in the case of anaesthesia. And unfortunately, this may not be adequately compensated by experience, insight and wisdom.

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