When should surgeons retire?

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Background: **Retirement policies for surgeons differ worldwide. A range of normal human functional abilities decline as part of the ageing process. As life expectancy and their population increases, the performance ability of ageing surgeons is now a growing concern in relation to patient care. The aim was to explore the effects of ageing on surgeons' performance, and to identify current practical methods for transitioning surgeons out of practice at the appropriate time and age.**

Methods: **A narrative review was performed in MEDLINE using the terms 'ageing' and 'surgeon'. Additional articles were hand-picked. Modified PRISMA guidelines informed the selection of articles for inclusion. Articles were included only if they explored age-related changes in brain biology and the effect of ageing on surgeons' performance.**

Results: **The literature search yielded 1811 articles; of these, 36 articles were included in the final review. Wide variation in ability was observed across ageing individuals (both surgical and lay). Considerable variation in the effects of the surgeon's age on patient mortality and postoperative complications was noted. A lack of neuroimaging research exploring the ageing of surgeons' brains specifically, and lack of real markers available for measuring surgical performance, both hinder further investigation. Standard retirement policies in accordance with age-related surgical ability are lacking in most countries around the world.**

Conclusion: **Competence should be assessed at an individual level, focusing on functional ability over chronological age; this should inform retirement policies for surgeons.**

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Introduction

The concept of retirement was first introduced in Germany in 1889. The retirement age was set at 70 years but, owing to the low life expectancy, very few people survived to claim this benefit[1]. Today, the statutory retirement age ranges from 50 to 70 years around the world; few professions have mandatory retirement ages. Policies on retirement age for surgeons are diverse and have undergone significant changes over time in different parts of the world. In a field where skill, ability to discern and memory are equally important, the increasing age of a surgeon has significant implications when it comes to safeguarding patient care. Increasing life expectancy has led to an ageing workforce. For example 17·6 per cent of practising surgeons in Canada were aged over 65 years in 2006. In Australia, 19 per cent of actively practising surgeons are over the age of 65 years[2], whereas in the USA there are reportedly 20 000 actively practising surgeons aged over 70 years[3].

The healthy human brain undergoes significant changes with age. There is a reduction in specific cognitive abilities, such as processing speed, executive functioning and episodic memory. A decline in motor skills with age is recorded to some extent, including decreased ability to learn new movement, reduced ability to reorganize and accommodate new information, and decreased ability to integrate motor and cognitive tasks[4]. The Cognitive Changes and Retirement Among Senior Surgeons (CCRASS) study[5] of 359 surgeons demonstrated an age-related cognitive decline over 6 years. Even though surgeons also face an age-related decline in brain function, it has been reported that they may age better than age-matched normative controls. In a study[6] of 308 subjects, surgeons outperformed age-matched controls in all age groups in a range of neuropsychological tests, including visual memory and psychomotor performance.

Several previous researchers have sought to elucidate the effects of the ageing process on a surgeon's performance. However, these remain poorly understood. The aim of the present review was to define what is known about the effects of ageing on surgeons' clinical performance. The implications of ageing on quality of care are used to inform policy development on surgical retirement.

Methods

A preliminary search of the literature on the effects of ageing on surgeons and their performance was first undertaken as a scoping exercise. The literature identified in this search was heterogeneous, making it impossible to formulate a question for a systematic review. Hence, a narrative review summarizing the current literature was conducted. A literature search based on modified Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines[7] was conducted in MEDLINE using the terms 'ageing' AND 'surgeon'. All articles on age-related changes in the biology of the brain and the effect of ageing on a surgeon's performance were included. In addition, relevant articles not identified in the initial search were hand-selected from reference lists. Only articles in the English language and those with full text available were included. No time limits were set for inclusion of articles. Articles in languages other than English, abstracts only and articles not relevant to the search criteria were excluded.

The primary aims of this review were to report the effects of ageing on the function of the healthy human brain, and to discuss this in the context of surgeons and their performance. Current policies on retirement among surgeons and comparable professionals around the world were investigated, included assessments for surgeons in practice, and for those transitioning out of practice. The relevant literature was used to suggest a practical method that allows transition of surgeons out of practice at the appropriate time and age.

Results

A total of 1811 articles were identified in MEDLINE; 36 were included in the final review (*Fig. 1*). The relevant results from these studies were described in terms of the effect of ageing on brain biology, individual variation in the ageing process and the impact of ageing on surgical performance.

General effect of ageing on brain biology

Studies on the effect of ageing on the biology of the brain were divided broadly into imaging and neuropsychological studies.

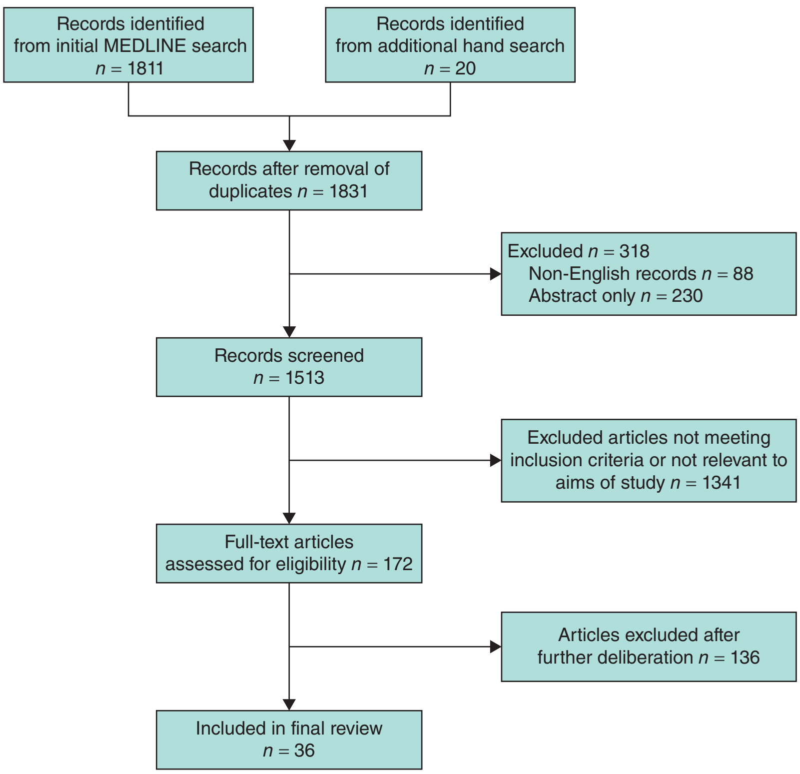

Fig. 1 Modified PRISMA flow chart for narrative review

Imaging studies: effect of ageing on brain biology

Longitudinal imaging studies on healthy volunteers based on CT and MRI found increases in ventricular size with advancing age, along with a reduction in overall volume of the healthy brain[8–10]. Structural changes accounted for 25–100 per cent of the erosion of cognitive abilities in older individuals[8,11]. Neuronal shrinkage and reduction in synapse numbers accounted for the grey matter changes in ageing brains[8]. Functional imaging studies (functional (f) MRI) of the ageing brain showed a correlation between reduced coordination between different brain regions responsible for higher cognitive functions, and poor performance in several cognitive domains. This was addressed by Andrews-Hanna and colleagues[12] in a study of 93 adults aged 18–93 years. It was found that, with age, neural activity not only becomes less coordinated between regions, but also more localized in certain areas, such as the prefrontal cortex. Moreover, ageing individuals who showed delocalized activity during execution of higher-level tasks performed better than those with localized brain activity[12,13].

Neuropsychological studies: effect of ageing on brain biology

Neuropsychological tests showed a generalized effect of ageing on multiple functions, related to areas identified by the imaging studies. Bieliauskas and co-workers[5] administered computerized cognitive tasks to 359 senior surgeons over 6 years, and found an age-related cognitive decline in specific skills related to attention, reaction time, memory and sensory changes in vision, visual processing speed and hearing.

Age-related effects on the biology of the brain are summarized in *Fig. 2*.

Individual variability

The studies in the review revealed considerable individual variation in the ageing process. This has been reported in terms of cognitive tests and imaging studies.

Variation in ageing: dexterous skills

It was found that older adults can often perform as well as young adults in several occupationally relevant tasks, such as typing, piano playing and aviation simulations, despite evidence of age-related decline in basic cognitive, perceptual and motor abilities[14–16]. This was reported to be a result of skills learning, or specialized training (managed by procedural memory functions) helping to maintain performance[17]. Hertzog *et al.*[18] also attested to this maintenance, and in some instances improvement, in specific trained skills in older adults. They studied evidence from animal models, aerobic fitness interventions, cognitive interventions and epidemiological studies, concluding that a cognitively enriched lifestyle can influence intellectual development and attenuate cognitive decline in late

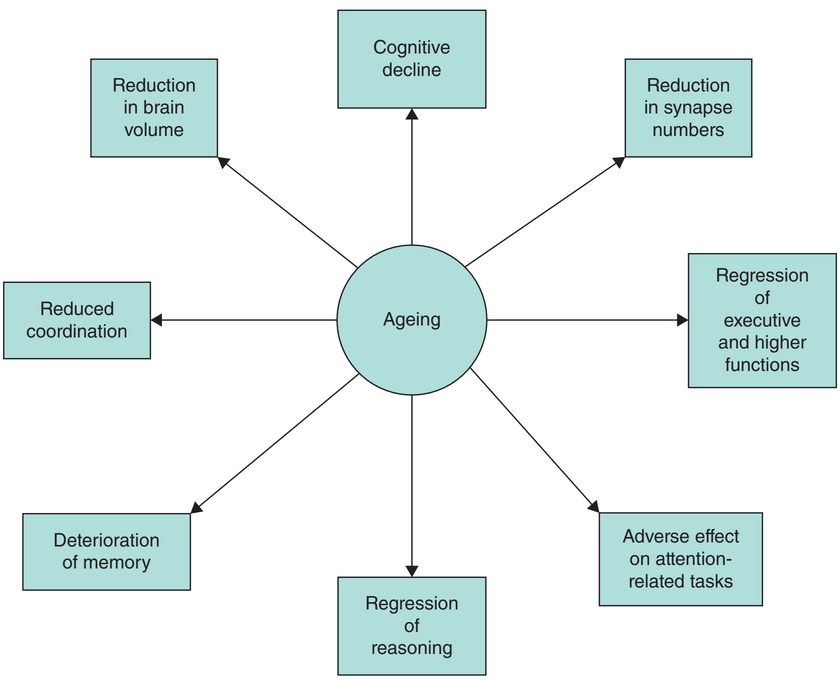

Fig. 2 Effect of ageing on the biology of the brain and its functions

adulthood and old age. Even though such lifestyle measures can help delay the inevitable, the ageing process remains inexorable, and even individuals who engage in optimal enrichment behaviours will experience cognitive decline at some point.

Variation in ageing: imaging studies

A possible neurological explanation for the variation in the ageing process was given by Cabeza and colleagues[19], based on PET and fMRI findings. They reported that hemispheric asymmetry in older adults can have a compensatory function, and high-performing older adults (with higher mnemonic scores) counteracted age-related neural decline through a plastic reorganization of neurocognitive networks.

Variation in ageing: surgical performance

This variability of the ageing process was also described in the performance of surgeons. In studies by Neumayer and co-workers[20] and Waljee *et al.*[21], it was found that effect of the surgeon's age was limited to surgeons who performed the procedure less frequently, or had less experience. Waljee and colleagues[21] stratified outcomes according to types of surgery, and their examination of files of 461 000 Medicare patients showed that older surgeons (aged over 60 years), particularly those with low procedure volumes, had higher mortality rates for the surgical procedures pancreatectomy, coronary artery bypass grafting and carotid endarterectomy. This was not true, however, for oesophagectomy, cystectomy, lung resection, aortic valve replacement or aortic aneurysm repair. The authors concluded that age of the surgeon cannot predict operative mortality; however, low volume of surgery undertaken by a surgeon could be implicated in the higher mortality noted in the study[21]. Defining what exactly is an adequate procedure volume for a particular surgeon remains elusive.

Further supporting the notion that not everyone ages in the same way, in his review on ageing and cognitive skills, Eva[22] noted that 'variability across the scores individuals receive tends to increase with age, thereby suggesting that strong individual differences exist. Although the average performance tends to be lower, many older individuals perform at levels equal to (or above) those of their younger colleagues. As such, decisions regarding continuing competence should be made at the individual level, rather than instituting mandatory retirement policies'.

A systematic review[23] of doctors' clinical experience and quality of healthcare reported lower-quality care among doctors who were in practice longer. The results of this review showed that 32 (52 per cent) of 62 studies reported decreasing performance with increasing years in practice for all outcomes assessed; 13 (21 per cent) reported decreasing performance with increasing experience for some outcomes, but no association for others; two (3 per cent) reported that performance initially increased with increasing experience, peaked and then decreased (concave relationship); 13 (21 per cent) reported no association; one (2 per cent) reported increasing performance with increasing years in practice for some outcomes, but no association for others; and one (2 per cent) reported increasing performance with increasing years in practice for all outcomes. This systematic review was based on all clinicians and did not focus on surgeons alone.

Impact of ageing on surgical performance

The main objective data regarding impact of ageing on surgical performance are mortality and morbidity data. Higher mortality rates were found with specific procedures: coronary artery bypass grafting and carotid endarterectomy, when performed by older surgeons[24]. Increased postoperative morbidity has also been reported in procedures performed by older surgeons. Surgeons aged 45 years or more had higher rates of recurrence following laparoscopic hernia repair, in a study by Neumayer and co-workers[20]. Duclos *et al.*[25] found that 20 years or more of practice was associated with increased postoperative complication rates after thyroid surgery; they concluded that surgeons aged 35–50 years performed better than their younger and older colleagues. In contrast to these reports, a few authors have demonstrated reduced complication rates with increasing surgeon age in certain procedures. Speed and acquisition of laparoscopic skills were found to correlate positively with the number of years after training in a study by Risucci and co-workers[26]; experienced surgeons performed better. The outcomes of complex alimentary tract procedures were found to be poorer among younger surgeons than their older colleagues[27].

There are few data regarding older surgeons and their compatibility with newer technology. Powers and co-workers[28] reported that older surgeons find it difficult to handle new minimally invasive technology, especially during a crisis situation. In that study, seasoned surgeons (aged over 55 years) were found frequently to relegate the use of unfamiliar technology to their assistants.

Age and cognitive skill studies

Few studies measured additional cognitive functions of older surgeons to elucidate the effect of ageing on their clinical performance. The CCRASS study[5] showed an expected age-related cognitive decline in various computerized cognitive tasks (taken from the Neurophysiological Test Automated Battery), such as verbal memory, reasoning and visuospatial ability. In contrast to this, Drag *et al.*[29] reported that the majority of practising senior surgeons performed at, or near, the level of their younger peers on all cognitive tasks, as did almost half of the retired senior surgeons. They concluded that older age does not inevitably preclude cognitive proficiency.

Table 1 Retirement ages for doctors in different countries[35–43]

	Retirement policy for doctors
USA	No mandatory age
Canada	65 years: minimum age
UK	No mandatory age
Ireland	65 years: minimum age
Germany	No mandatory age
Italy	No mandatory age
Australia	No mandatory age
India	65 years: public sector only
Russia, China	60 years for men, 55 years for women

Discussion

Ageing is an inevitable and complex process associated with both structural and neurophysiological changes in the brain, resulting in varying degrees of cognitive decline.

There is a decline in memory, reaction and movement time. There is a regression of reasoning and executive functions associated with planning, arranging and initiating, along with a reduction in cognitive processing efficiency. Ageing also adversely affects performance on tasks requiring sustained attention, specific attention and inhibition[4]. Age-related changes in the surgeon might have wider implications in the highly stressful environment of an operating theatre, compared with other specialties such as general practice[25].

Variations in the effects of ageing among individuals have been reported. Specialized training employed as a protective factor may mitigate the course of performance decline. In the surgical profession, a number of factors may influence age-related change in performance. One of the common factors described in the literature is surgical volume, with higher volumes of procedures being linked to a reduction in age-related decline. This suggests that, as the effects of the ageing process can vary among individuals, functional age may be a more valid measure of competence than chronological age.

Studies concerning age of the operating surgeon and mortality or postoperative complications have shown heterogeneous results. These must be interpreted with caution, as the studies were based largely on administrative data. It also has to be noted that most of these studies used only surrogate markers such as postoperative outcomes to examine the effect of ageing on surgeons' performance. This may not be the most accurate method because postoperative outcomes can be affected by multiple confounding factors. Hence, even though definite changes occur in the biology of the human brain with age, the exact mechanism and effect of this process on performance is still uncertain, and the current theories on this are speculative.

Considering ageing and its effect on the brain, most professions, particularly those affecting public safety, have mandatory retirement policies. The retirement age for commercial airline pilots is 65 years in the USA, raised from 60 years in 2007 after the Fair Treatment for Experienced Pilots Act was introduced[30]. For air traffic controllers, retirement is mandatory at 56 years of age in the USA, and 60 years in the UK[31,32]. Other examples include: Federal Bureau of Investigation agent in the USA (57 years), National Park Ranger (57 years), lighthouse operator (55 years) in the USA, and federal judges (70 years) in Australia, Brazil and certain states in the USA[33,34].

In most countries around the world, there is no mandatory retirement age for doctors[35–43]. Countries such as the UK and Germany recently phased out their policies on a mandatory retirement age. Minimum retirement age and statutory retirement ages for doctors are limited to public sectors only, and older professionals can continue practising in the private sector. Retirement policies for doctors are diverse in different countries (*Table 1*), and a universal consensus on this is still lacking. Considering the potential impact of a surgeon's ability on patient outcome, the question arises whether surgeons should be considered equivalent to professionals in high-risk jobs such as air traffic controllers or pilots. If so, is age the best indicator to determine the ability of a surgeon? Should there be a bespoke assessment to determine retirement for a surgeon?

Assessments and regular appraisals for trainee doctors have traditionally been the focus of training bodies, with relatively little attention given to assessment of older or qualified surgeons in practice. The CanMEDS 2015 framework by the Royal College of Physicians and Surgeons of Canada[44] has introduced a Competence by Design (CBD) project. This intends to move away from certifying physicians solely on the basis of time spent on rotations and activities, in favour of assessing achievement based on attained milestones of competence. CBD is described in terms of six stages: transition to discipline, foundations of discipline, core of discipline, transition to practice, continuing professional development and, finally, transition out of practice.

Currently, certification of a surgeon is based on successful transition to clinical practice. A number of assessments to test this milestone are available, with every training body employing specific criteria. Global professional assessments include workplace-based assessments looking at knowledge, clinical judgement, technical skills, and professional behaviour and attitudes[45]. Definite measures to assess continuing professional development, including maintenance of competence and advanced practice, are also in place.

The final stage of a doctor's career, transition out of practice, has received relatively little attention. This stage requires doctors to adapt to their changing healthcare role. It is difficult to assess this milestone in experienced older surgeons with excellent track records, who may not necessarily publish the outcomes of their clinical practice in the later years of practice. Hence, defined criteria to assess when a doctor has reached this milestone are not available. This is despite these assessments being of equal importance to, if not more important than, those evaluating training competence, because of their significant potential effect on patient safety. There is also less focus on other options such as non-clinical roles that can be assumed by senior surgeons: mentoring, teaching and academic surgery. Increased involvement in these roles may allow smooth transition out of clinical practice, with the added advantage of continued involvement in practice development. Assessments for older surgeons are being conducted in certain centres around the world. These can be compared with periodic surveillance of older drivers[46].

Even though a definite retirement age for surgeons is lacking, in 2012 compulsory 5-yearly revalidation was introduced by the General Medical Council (GMC) in the UK, in order to hold a licence to practise. This is in place for both licensed doctors and doctors in training. There is a responsible officer for every doctor, who makes recommendations regarding the doctor's practice to the GMC, based on which a decision is made to continue the doctor's licence[47]. However, surgical ability and the impact of ageing would be difficult to assess based only on revalidation criteria, as this focuses on all medical practitioners rather than surgeons in particular.

Similarly, in the USA there has been increased screening of older doctors in individual healthcare associations. In 2012, Stanford University Medical Center introduced compulsory 2-yearly physical examination, cognitive screening and peer assessment of clinical performance for all physicians aged 75 years. Age 75 years was chosen owing to the well documented increase in the incidence of Alzheimer's disease from that point. The University of Virginia also has intermittent assessment of doctors after 70 years of age[40]. The Aging Surgeon Program was introduced at Sinai Hospital of Baltimore in 2014. It is a 2-day confidential evaluation of physical and cognitive function for surgeons. They suggest a 2–3-yearly evaluation (depending on the hospital's reaccreditation cycle) for all surgeons aged 70 years or more[3]. However, poor performance at any of these tests does not result in dismissal of the surgeon. The matter is initially discussed between the surgeon and their hospital, at which stage the decision to retire would still be with the surgeon, unless there has been gross negligence. This requires substantial insight on the part of the surgeon[40].

If the decision regarding retirement age is at the discretion of the surgeon, balanced decisions are difficult. In the survey-based CCRASS study[48], the majority of the surgeons (60 per cent) who had not made a decision to retire said their decision would be based on skill level rather than age. However, this is based on their perceived cognitive ability, which is not predictive of their objective cognitive ability. This dependency on perceived cognitive ability may lead to premature, or belated, decisions to retire[48].

In addition to cognitive assessment, physical tests and other assessments, and even imaging tools such as fMRI, could be useful in the objective assessment of age-related changes in the brain. Using fMRI to compare novices with experts has identified separate and specific regions of interest in the brain. Functional imaging studies also show differences in brain functioning related to various measures of education[49,50] and changes as a result of cognitive training[51,52]. It could be argued that fMRI can be used to assess these effects, not only on initial surgical skill acquisition and refinement but also on skill retention. One such study[53] using fMRI identified a potential impact of ageing on ability; the authors found intermediate-level surgical trainees to be most proficient in the objective assessment of knot-tying ability, compared with novices and experts aged over 35 years.

The ageing process in the brain does affect surgical ability, but extent in an individual is still not known. There is little evidence in the literature to support a one-size-fits-all model, to determine retirement policy for surgeons. Intermittent assessments may serve as a method to base decisions on retirement from the operating theatre. Longitudinal data will be required to see whether these assessments can individualize the age of retirement for surgeons and thereby maintain patient safety. For surgeons at the cusp, transitioning out of clinical practice may be supported by increased involvement in mentoring, training and academic surgery.

Disclosure

The authors declare no conflict of interest.

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