Anaesthesia in the elderly

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Abstract

Older people are undergoing increasingly complex surgery with much greater mortality and morbidity than the younger adult population. In this article, we discuss the physiological changes that take place in the older patient, and how these may affect anaesthetic technique. Perioperative risk in the elderly is discussed, with focus on emergency surgery and frailty.

Keywords Anaesthesia; elderly; frailty; perioperative; surgery

Royal College of Anaesthetists CPD Matrix: 1A01, 1A02, 2A03

Learning objectives

After reading this article, you should be able to:

- recall the physiological changes that occur with ageing
- describe the modifications in technique necessary when anaesthetizing older people
- list the risk factors for the development of postoperative delirium
- list the factors associated with an increase in perioperative morbidity and mortality

The demographics of the UK population are changing, placing additional pressure on finite NHS resources: 1.6 million residents are now aged over 85 years, compared to only 200,000 when the NHS was founded in 1948. The number of older people undergoing surgery is increasing and in 2014-5, the over 75s accounted for 22% of all surgical procedures carried out in England. Older people are undergoing increasingly complex surgical procedures, and surgery in older patients carries a greater risk of mortality and morbidity than that of the younger adult population.

Surgical emergency presentations are increasingly common in older patients, with perioperative risk disproportionately high in this patient group.[1] Major trauma (defined as an injury severity score greater than 15) now more commonly occurs in the over 65s than younger patients, with a fall from less than 2m height the most common mechanism.[2] Perioperative risk is particularly high for emergency colorectal procedures, with mortality over 40% in octogenarians.[3]

Pathophysiology of ageing

The pathophysiology of ageing at a cellular level is still a matter of much research and debate. In summary, ageing is thought to occur through a combination of genetically pre-programmed cell death (the telomere theory) and cellular damage occurring throughout life (the free radical and somatic mutation theories). Overall, there is a reduction in the number of cells within an organ, and a decline in function of the remaining cells.

At a macroscopic level, the decline in organ function begins in early adult life, but often does not become clinically evident until almost all organ reserve is lost. Organ failure occurs either when the organ function declines to a point where it can no longer support life or when the organ cannot increase its function sufficiently to mount a physiological response to a stressor, for example acute illness, anaesthesia and surgery. Functional decline in the cardiovascular, respiratory, renal, central nervous, haematological and musculoskeletal systems are of greatest concern perioperatively, and may influence outcome from elective or emergency surgery. Anaesthetists must therefore be familiar with the normal physiology of ageing, of which there is considerable individual variability, as well as the consequences of accumulated comorbidities, cognitive impairment, frailty and polypharmacy.

Respiratory

Physiology: The thoracic cage becomes more rigid due to calcification of the costal cartilages, leading to reduced thoracic wall compliance. The elastic fibres of the alveolar septae undergo degeneration, leading to:

- Loss of support for alveoli and small airways, resulting in airway collapse during normal tidal breathing. This is a major cause of ventilation-perfusion (V/Q) mismatch, and is the main contributor to the increased alveolar–arterial (A–a) gradient seen in the elderly.
- An increase in lung compliance, which partially offsets the reduced thoracic wall compliance.

The architecture of the alveolae also changes with advancing age. Total alveolar surface area decreases and there is thickening of the delicate alveolar-capillary membrane, both of which reduce lung diffusing capacity and contribute to the raised A–a gradient.

The result of these changes is a clinical picture very much like that of mild chronic obstructive pulmonary disease (COPD), i.e. an increase in residual volume and functional residual capacity (FRC). FRC is the point at which the inward lung elastic forces match the outward force generated by the thoracic cage. In older people, FRC occurs at a higher lung volume: anterior–posterior thoracic cage diameter is therefore increased, with flattening of the hemi-diaphragms. Kyphosis may also contribute to adverse lung mechanics. Similar to patients with COPD, these mechanical changes make inspiration less efficient, with an increase in energy expended during inspiration. These changes, along with intercostal and diaphragmatic muscle atrophy, make the elderly more susceptible to respiratory fatigue.

Anaesthetic considerations:

- Edentulous patients may be difficult to ventilate with bag and mask, but are generally easier to intubate.
- The upper airway is prone to collapse during recovery from anaesthesia, resulting in snoring and hypoxaemia.

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- There is a progressive decrease in protective laryngeal reflexes with ageing, which increases the risk of aspiration.
- The decrease in respiratory compliance, changes in lung mechanics and inspiratory muscle atrophy makes older patients more prone to postoperative respiratory failure.

Cardiovascular

Physiology: Arteries become less elastic with age as the tunica media undergoes fibrosis. This leads an increase in systolic blood pressure. Systolic hypertension has two major consequences:

- The left ventricle must generate a greater pressure to eject blood into a stiffened aorta.
- The velocity of the arterial pressure wave is increased. Normally, the reflected pressure wave reaches the heart in early diastole, and is responsible for the bump after the dicrotic notch in the arterial pressure waveform. However, when arteries are stiffened, the reflected arterial pressure wave reaches the heart in late systole, which further increases the afterload against which the left ventricle must pump.

In response to raised afterload, the left ventricle undergoes hypertrophy. Ventricular hypertrophy impairs diastolic relaxation and the left ventricle becomes increasingly dependent on atrial contraction for filling. This physiological diastolic dysfunction can be exacerbated by comorbid disease, for example systemic hypertension and ischaemic cardiomyopathy.

There is a reduced ability to increase cardiac output in response to hypovolaemia, due to:

- a reduction in β-receptor responsiveness, which limits the ability of the left ventricle to increase contractility
- fibrosis of the carotid sinus, which impairs the ability of the baroreceptors to rapidly increase heart rate in response to a decrease in blood pressure
- a decrease in venous compliance, which impairs the venous buffering mechanism.

In addition, the elderly are more prone to supraventricular tachyarrhythmias due to fibrosis of the sino-atrial node and a large reduction in the number of pacemaker cells. The onset of atrial fibrillation can seriously impair the filling of the left ventricle, with a consequent reduction in cardiac output.

Anaesthetic considerations:

- Prolonged arm-brain circulation time delays onset of anaesthesia when using intravenous induction agents, but in theory increases the speed of onset of a gas induction. In reality, however, the duration of inhalational induction is usually prolonged due to the reduced alveolar diffusion and the increased *V/Q* mismatch that occurs with advancing age.
- The elderly are more prone to intraoperative hypotension, especially at induction of anaesthesia, and are less able to adequately compensate.
- The reduced cardiac responsiveness to β-agonists means that drugs such as ephedrine (a mixed α- and β-agonist) become less effective with advancing age.
- Use of oesophageal doppler cardiac output monitoring may be less accurate in the elderly, as the aorta is poorly compliant.
- The combination of changes to cardiovascular and respiratory physiology with ageing result in a decreased oxygen uptake and oxygen delivery, and thus a greater perioperative risk of myocardial and cerebral ischaemia.

Neurological

Physiology: There is a progressive decline in brain mass from approximately 50 years of age. In older people, this gives the appearance of cerebral atrophy on CT. Though there is a decrease in both grey and white matter, the resulting decrease in cognitive function is usually modest with short-term memory most often affected. Cerebral blood flow (CBF) decreases 10–20% which, as CBF is tightly coupled to brain metabolic rate, is a result of the reduction in brain mass. Synthesis of some neurotransmitters (e.g. dopamine) is reduced, as are the number of receptors and binding sites. Loss of dopaminergic neurons results in Parkinson's disease, while loss of cholinergic neurons is implicated in the development of Alzheimer's disease. Indeed, cognitive impairment becomes increasingly common with advancing age, affecting 20% of patients aged over 80 years old.[4] Sensory impairment is also common: deafness is very common in older people and visual impairment affects around a fifth of those aged over 75.

Older people are more likely to experience neurological dysfunction following surgery:

- Delirium is defined as a disturbance of consciousness that is accompanied by a change in cognition that cannot be better accounted for by a pre-existing or evolving dementia. Postoperative delirium (POD) occurs in over 20% of those aged over 65, usually develops in the first few postoperative days, and is usually temporary. It has a fluctuating course, with abnormal circadian rhythm, inattention, disorientation and memory deficit. POD may be sub-classified as hyperactive, hypoactive (which carries a higher mortality), or mixed variation. POD is independently associated with increased mortality, increased length of hospital stay, functional disability and discharge to long-term care institutions.[5] Risk factors for the development of POD include type of surgery (high-risk groups include cardiac surgery, emergency surgery and following hip fracture) and patient-specific factors: increasing age, pre-existing cognitive dysfunction, lower educational attainment, previous stroke.
- Postoperative cognitive decline (POCD) is a subtle impairment of memory, concentration and information processing usually lasting weeks or months, that is distinct from delirium and dementia. The incidence of POCD is difficult to determine, partly because there are no formal criteria for its assessment and diagnosis, but is thought to be in the order of 10% at 3 months. Recognition of POCD is important as it is associated with an increased mortality and may result in a functional step-down in social circumstances, for example from residential care to nursing care.[5] The cause of POCD is unknown, and several hypotheses exist. Risk factors for the development of POCD are the same as those of POD, with cardiac surgery carrying the greatest risk. While it is tempting to think that avoidance of general anaesthesia may prevent POCD,

studies have failed to show that spinal anaesthesia has any protective effect when compared to general anaesthesia.[6]

Anaesthetic considerations:

- Minimum alveolar concentration decreases by 6% per decade over the age of 40.
- Bispectral index monitors or entropy monitors may be used to guide depth of anaesthesia: failure to reduce the doses of anaesthetic agents for induction and maintenance of anaesthesia may result in a relative overdose with significant resultant hypotension.
- Opioids are twice as potent in the elderly, due to an increase in brain sensitivity with advancing age. In addition, the clearance of morphine and its metabolites is decreased.
- Benzodiazepines should be avoided: their effects may extend into the postoperative period.
- Pain is under-recognized and under-treated in the elderly and inadequate analgesia contributes to postoperative morbidity: delirium, cardiorespiratory complications and failure to mobilize. Older people are more reluctant to acknowledge and report pain, and pain assessment may be more difficult, especially in those with cognitive impairment. Simple analgesics such as non-steroidal anti-inflammatory drugs (NSAIDs) are often contraindicated. Instead, multimodal analgesia may include non-pharmacological methods, for example, postural support, pressure care and patient warming.

Renal

Physiology: From the age of 30, there is a progressive loss of glomeruli with a corresponding reduction in renal blood flow. This results in a decrease in glomerular filtration rate and creatinine clearance, but serum creatinine concentration remains approximately the same due to a concurrent reduction in muscle mass. In addition, the kidney is especially susceptible to damage by comorbid disease (e.g. hypertension and diabetes), and by the nephrotoxic effects of the pharmacological management of comorbidities (e.g. diuretics, ACE inhibitors, NSAIDs). Obstructive nephropathy is common in elderly men, due to age-related benign prostatic hypertrophy.

Fluid management is more challenging in the elderly:

- The kidney has altered responsiveness to vasoactive substances: the effect of vasoconstrictor stimuli is enhanced and that of vasodilator substances is reduced.
- Sodium handling is impaired, and the kidney is less responsive to ADH and aldosterone.

Haematological

Physiology: Anaemia is the most common haematological abnormality in older people, with a prevalence of 20.1% in elderly men and 13.7% in elderly women. Decreased haemoglobin concentration may be related to a physiological decline in marrow haemopoiesis or the result of a poor diet, but anaemia should not be considered a normal part of ageing. Preoperative anaemia must be investigated to exclude gastrointestinal bleeding, for example as a result of colonic polyps or carcinoma, gastric carcinoma, angiodysplasia or NSAID use.

Anaesthetic considerations:

- Anaemia is associated with perioperative myocardial infarction, falls, impaired wound healing and poor rehabilitation.
- Preoperative iron replacement should be offered to anaemic patients: oral replacement is preferable, but if there is insufficient time before urgent surgery then intravenous iron may be considered.
- UK adult guidelines recommend transfusion at a haemoglobin threshold of 70 g/L.[7]

Hepatic

Physiology: There is a reduction in liver mass and hepatic blood flow with advancing age. This results in a decrease in hepatic plasma protein synthesis, and hepatic metabolism of certain drugs.

Anaesthetic considerations:

- Hepatic clearance of many anaesthetic drugs is reduced. For example, aminosteroid neuromuscular blocking agents may have a prolonged duration of action, mandating routine neuromuscular monitoring. In contrast, the duration of action of (cis-)atracurium is unaffected by age as it is independent of hepatic metabolism.
- Decreased albumin concentration alters the distribution of many protein-bound drugs.
- Decreased plasma cholinesterase concentration results in slower metabolism of mivacurium and suxamethonium, though this is rarely of clinical significance.

Musculoskeletal

Physiology: There is a generalized loss of muscle mass with advancing age, known as sarcopenia. Around 6 kg of muscle is lost by the age of 80 years. Together with arthritic and osteoporotic skeletal changes, the loss of muscle function increases the likelihood of fragility fractures requiring orthopaedic surgery, and of impaired rehabilitation following all types of surgery. Reduced postoperative mobility predisposes the elderly to venous thromboembolic disease and skin pressure necrosis, which is also in part due to the reduction in subcutaneous tissue.

Anaesthetic considerations:

- Additional care must be taken with intraoperative patient positioning and padding of pressure points, paying special attention to skeletal deformities, for example kyphoscoliosis and fixed flexion deformities.
- An older person's skin is especially friable and care must be taken when removing adherent items, for example diathermy pads and tape from eyelids.

Thermoregulation

Physiology: Thermoregulation is impaired with advancing age. There is a reduction in heat production, as basal metabolic rate decreases by approximately 1% per year. This is compounded by an increase in heat loss, due to a lower peripheral vasoconstriction threshold and a reduced responsiveness to peripheral vasoconstrictors.

Anaesthetic considerations:

- Older people are at especially high risk of intraoperative hypothermia and active intraoperative warming should be considered, even for short procedures.
- In the postoperative period, the elderly may lack the muscle bulk for effective shivering or they may have insufficient cardiopulmonary reserve to meet the increased oxygen demands of shivering.

Pharmacology

The age-related changes described above impact on the pharmacokinetics of many drugs. Older people have a decrease in total body water with reduced volume of the central compartment: a given bolus of water-soluble drug will result in a higher serum drug concentration. Older people also have a higher proportion of body fat, which increases the volume of distribution of many lipid-soluble drugs, thus prolonging their action. In addition, the distribution of highly protein-bound drugs is altered through the reduction in plasma protein concentration. The circulating albumin concentration (the main binding protein for acidic drugs) decreases with age, while α-1-acid glycoprotein concentration (the main binding protein for basic drugs) increases.

Anaesthetic considerations: The changes in pharmacokinetics in the elderly have implications for anaesthesia:

- A given bolus of intravenous induction agent results in a higher plasma concentration, which leads to hypotension. The dose of induction agent must therefore be reduced.
- The effects of benzodiazepines given at induction of anaesthesia may persist into the postoperative period.

Definition of 'elderly'

The term 'elderly' is somewhat arbitrary defined on the basis of chronological age, usually as those aged over 65 years. This definition is increasingly recognized as inadequate for the purposes of surgical risk prediction, as it represent a physiologically diverse group of people with varying amounts of comorbidity. For example, a 65 year old patient without comorbid illness has a very different perioperative risk to that of a 95 year old with frailty and dementia. It has been suggested that rather than by chronological age, 'elderly' should be defined as those with a monthly mortality of greater than 1%.[8] 'Elderly' by this definition would also include younger patients with complex comorbidities.

Frailty

Frailty is a decline in physiological reserve across multiple organ systems such that the ability to compensate effectively for external stressors is compromised, which may result in adverse outcomes such as prolonged hospital stay, worsening disability and death. Most frail older people also have medical comorbidities, but frailty is a distinct entity from comorbidity. Around 10% of those aged over 65 years are frail, rising to 25–50% in those aged over 85 years.[9] At age 95, all patients are frail and are therefore vulnerable to adverse surgical outcomes, even after a seemingly minor stressor.

The assessment of frailty in the perioperative setting is challenging. Frailty is often assessed through an 'end of the bed' evaluation of the degree of cachexia, sarcopenia and slowness of movement, but identifying only those with low BMI as vulnerable would omit many high-risk patients. Likewise, polypharmacy does not necessarily indicate frailty: patients with advanced dementia are often prescribed relatively few medications, but are at much greater risk of POD.

While there are a number of tools available for the assessment of frailty (Fried criteria, PRISMA 7 questionnaire, Rockwood frailty index, timed 'up and go' test), no method of quantifying frailty is in routine clinical use in the perioperative period. Some assessment tools have shown promise, for example, the Fried assessment tool has been shown to independently predict postoperative complications, length of stay and dependency on discharge.[9] However, frailty assessment by the Fried criteria requires special equipment (a hand-held dynamometer) and is not universally applicable to the inpatient population, as many of the most vulnerable will be unable to mobilize (gait speed is one component of the scoring system).

Perioperative risk

When approaching discussions about perioperative risk, what actually matters to a patient is an individual risk of dying or experiencing serious morbidity and the likelihood of return to the preoperative level of function and independence. This individual risk stratification is, of course, very difficult to quantify. In broad terms, the rate of adverse postoperative outcomes increases with physiological age, comorbidity and frailty. These postoperative complications are predominantly medical rather than surgical. Outcomes are considerably worse if surgery is unplanned and mortality and morbidity for the 'big three' surgical emergencies of older people (ruptured abdominal aortic aneurysm, laparotomy and hip fracture) is relatively static, despite improvements in outcome following similar procedures carried out electively.[10] Preoperative optimization must be balanced against the risk of delaying surgery; delay before emergency hip surgery and emergency laparotomy is associated with poorer postoperative outcomes, suggesting that optimization and surgery should occur concurrently rather than consecutively. Additionally, consideration should be given to performing an initial less invasive operation (for example defunctioning colostomy) to allow patient stabilization prior to definitive surgery. Early input by an elderly care physician is recommended, in the preoperative phase if time allows.

Historically, fewer elderly patients have been admitted to a critical care ward postoperatively than would have be predicted on the basis of type of surgery or illness severity criteria. Postoperatively, all patients with a predicted mortality of >10% should be admitted to a critical care ward, though there remains significant inter-hospital variability in the UK.[3]

In summary, the decline in physiological reserve makes surgery and anaesthesia in older people more challenging, and carries much greater perioperative risk. Effective multidisciplinary team-working and timely surgery together with a sympathetically delivered anaesthetic may mitigate some of this additional risk. ◆

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