# I. Geriatrics (Anesthesia Text)

# Introduction

Approximately 1/3 of surgical patients are 65 and older, although this number is rising. The incidence of perioperative morbidity and mortality is higher in geriatric patients, however this is most likely due to age-related diseases themselves and not the age itself (ie a healthy 70 year old may be at lower risk than a 55 year old with multiple comorbidities). It is helpful to think of elderly (and all) patients in terms of organ reserve function – as individuals age past their 30s or 40s, the "functional reserve" of each organ system begins to decline

# Aging – CNS changes

**Definition**

**Structural changes:**

- Loss of neural tissue
- Thickened leptomeninges in spinal cord
- Decreased number of serotonin, acetylcholine, and dopamine receptors

**Functional changes:**

- Reduction in cerebral blood flow (decreases about 10-20%, in proportion to neuronal loss)
- Decline in memory, reasoning, perception
- Disturbed sleep/wake cycle
- Increased threshold for many sensory modalities including touch, temperature, sensation, proprioception, hearing, and vision

As one ages, there is a gradual decrease in brain size, thought to be due to decreased neuronal size. This results in widened sulci and enlarged ventricular volume. This "shrinkage" of the brain leads to a larger subdural "space," which explain why elderly patients are at risk for a subdural hematoma.

The number of neuroreceptors and neurotransmitters decrease even in the absence of dementia or recognized neuro-degenerative disease. Most significant declines are in acetylcholine and serotonin in the cortex, dopamine receptors in the neostriata, and dopamine levels in the substantia nigra and neostriata.

**Common Anesthetic Medication Classes and CNS Effects on Aging**

- Volatile anesthetics: Elderly patients require decreased inspired concentrations of volatile anesthetics. MAC decreases by approximately 6-7% every decade after age 20.
- Propofol: Both induction doses and maintenance doses of propofol are decreased. Propofol's hemodynamic effects can be greatly exaggerated in older patients as well.
- Opioids: Elderly patients require smaller doses for similar effect and have an increased incidence of respiratory depression and increased duration of systemic and neuraxial effects. This is due to decreased volume of distribution of these agents, among other reasons.
- Benzodiazepines: Display a significant increase in duration of action. Long-acting benzodiazepines such as lorazepam and diazepam have been associated with delirium in the elderly.
- **Atropine: dosing may need to be increased to achieve a given heart rate response in the aging patient.**
- Neuromuscular Blockers: Aging in and of itself does NOT increase sensitivity to muscle relaxants at the NM junction, however, co-morbidities often associated with aging (i.e. renal dysfunction) may do so.
- Neuraxial anesthesia in the elderly can be problematic as exaggerated spread of local anesthetic can occur in the epidural

space. Conversely, a longer duration of action is expected from a spinal anesthetic.

**Postoperative Cognitive Dysfunction**

Postoperative cognitive dysfunction (POCD) is a cognitive disorder unique to patients after anesthesia. Unlike delirium, patients with POCD are not acutely confused or agitated. In some studies 10% of older patients (age > 60) developed POCD in the 3 months following noncardiac surgery. Its occurrence has been associated with increased mortality rate. Its etiology is likely multifactorial and includes drug effects, pain, underlying dementia, hypothermia, and metabolic disturbances.

Both Postoperative delirium and cognitive dysfunction are higher in elderly patients.

## II. Cardiovascular changes.

As cardiac output is generally coupled with metabolic needs, aging patients have a reduced (but normal) cardiac output.

Systolic function can be remarkably preserved . Cardiac responsiveness to adrenergic stimulation is reduced, however, and therefore maximal heart rate (and cardiac output) falls with age. Also, the heart becomes thicker with age, which impedes diastolic filling, further affecting cardiac output and increasing reliance on normal sinus rhythm. Geriatric patients may be highly pre-load dependent, with small decreases in preload (hemorrhage, decreased PO intake) having profound effects on cardiac output. Mid-systolic ejection murmurs are common and are secondary to aortic cusp thickening

Normal physiologic changes of the vascular system include atherosclerosis (leading to hardened arteries, reduced vascular compliance, and a widened pulse pressure), increased arterial wall thickness and decreased β2-mediated vasodilation. Vascular impedance increases, which ultimately leads to increased myocardial wall stress and

oxygen consumption. Interestingly, afterload due to vascular impedance can increase even if SVR is unchanged – Nichols et al. studied 22 patients undergoing catheterization and found that there was no difference in aortic input resistance between hypertensive and non-hypertensive patients, but impedance was higher in the hypertensive group (142 vs 72 dyne-sec/cm5, $p < 0.005$) [Nichols et al. Circulation 74: 455, 1986]. Arterial pressure waves, which normally reflect back towards the heart (arriving during diastole in young, healthy patients), travel more quickly and reach the heart during systole, forcing it to pump against itself and significantly reducing ventricular efficiency

Aging also produces a state of beta-adrenergic insensitivity, and elderly patients are markedly less responsive to beta-agonists (ex. isoproterenol). Alpha sensitivity remains. The adrenal tissues atrophy some with age, but circulating norepinephrine levels increase ~ 2-4 fold in order to compensate for beta insensitivity . The end result is that autonomic responses are impaired. Furthermore, elderly patients seem to respond differently to hypotension – a study of 9 patients aged 74 years and 7 patients aged 27 years suggested that both groups maintained MAP values when subjected to a 60 degree tilt, however the young adults did so by increasing cardiac contractility and heart rate, whereas elderly patients relied on increased vascular resistance [Shannon et al. Am J Cardiol 67: 1110, 1991]

# Geriatrics: Pulmonary changes

**Definition**

**Ventilatory responses to hypoxia, hypercapnia, and stress are reduced**, while the **depressant effects of both intravenous**

**agents** (benzodiazepines, opioids) **and volatile anesthetics are more pronounced**.

Elderly lungs **lose tissue elasticity** and demonstrate **increases in lung compliance** (much like emphysema), however, **chest wall compliance decreases**, so the **net pulmonary compliance is virtually unchanged.** Breakdown of alveolar septae and loss of elasticity results in a 15% reduction in functional alveolar area by 70 years of age .

**There is increases in anatomic and alveolar dead space and decrease in diffusing capacity and increase in ventilation- perfusion mismatch.** (**increased ventilation-perfusion mismatch is the most important reason for increased A-a gradient with aging**).

Large airways get bigger and small airways get smaller, which has a neutral effect on total resistance. Total lung capacity decreases slightly, FRC and residual lung volumes increases(Residual volume increases by 7% per decade), and thus vital capacity, ERV and IRV decreases.

Closing capacity approaches FRC, thus it becomes possible for elderly patients to collapse their airways during expiration. Data from Rose's prospectively collected PACU patients (24,157) suggested that the risk of critical respiratory events postoperatively is almost twofold higher (RR 1.92, adjusted relative odds ratio 1.54) in patients > 60 years of age .

At 44 years of age, closing capacity and FRC equalize in the supine position, and at 66 years of age, in the upright position.

Loss of height and calcification lead to diaphragmatic flattening and barrel chest, decreasing mechanical efficiency which is worsened by loss of muscle mass. Work of breathing is increased.

**Pulmonary Changes in the Elderly**

- **Decreased ventilatory response to hypoxia, hypercapnia, and stress**

- **Increased response to opioids, benzodiazepines, volatile anesthetics**
- Diminution of elastic recoil, less surfactant, increased lung compliance
- Decreased mechanical efficiency
- **Increased closing capacity** and **increased V-Q mismatching**

# III. Pharmacology in the elderly

**Definition**

With aging, decreased muscle mass and increased body fat result in overall decrease in total body water. Thus, lipid-soluble drugs have higher plasma concentrations and water-soluble drugs have lower concentrations.

Also, GFR and hepatic function decline resulting in increased duration of action of several common anesthetics (see below).

Protein binding via albumin is usually decreased (targeting drugs such as barbiturates, benzodiazepines, opioids), resulting in increased action of those specific drugs.

The action of local anesthetics, however, is usually decreased (this is not generally the case for neuraxial use of local) because they are bound by alpha-1 acid glycoprotein, which increases with age.

MAC declines by approximately 4-6% per decade over 40. Volatile anesthetic agents' myocardial depressant effect is augmented in elderly patients. Recovery from volatile anesthesia is prolonged for reasons outlined above.

Propofol is more likely to cause apnea and hypotension; requirement in the elderly population is reduced by as much as 50%.

Dose requirements for fentanyl, alfentanil, and sufentanil are all reduced by as much as 50%. Clearance is a factor for remifentanil – thus dosing requirements for remifentanil in particular may be even further reduced.

Dosing requirements are reduced by 50% for Midazolam as well and half-life is prolonged up to 4 hours. The perioperative use of Midazolam (and other benzodiazepines) is also associated with an increased risk of postoperative delirium.

Aging does not significantly change the response to succinylcholine or NMDBs. Those drugs that depend on renal clearance (pancuronium) may produce prolonged block due to diminished GFR in the elderly. Renally excreted drugs (rocuronium and vecuronium) may also have prolonged action if hepatic function is diminished in an elderly patient as well.

Be aware of the generally greater number of home meds elderly patients are taking and possible drug-drug interactions pertinent to our practice.

**Muscle relaxants in elderly.**

There is approximately a 1% per year reduction in cardiac output after 30 years of age, and a reduction in cardiac output would result in slower distribution of NMB drugs to the neuromuscular junction. This subsequently results in a slower onset of block in elderly patients.

Decreased cardiac output and age-related glomerular sclerosis lead to decreased GFR of about 1% per year after age 40. Therefore, drugs that undergo renal excretion may be significantly prolonged.

Hepatic blood flow falls by about 1% per year and liver mass is reduced in elderly patients, which leads to a reduced elimination of drugs that undergo hepatic metabolism. Additionally, clinically significant prolongation of action occurs with repeated dosing or large boluses in the elderly.

Decreases in muscle mass, reductions in total body water, and an increased proportion of total body fat leads to mild changes in volume of

distribution, and doses based on body weight will lead to a prolonged effect in the elderly.

Reduced plasma protein binding does not effect NMBDs because they are not highly protein bound. Potency is also unchanged for NMBD use in the elderly compared with younger patients.

The elderly are also more prone to hypothermia due to impaired temperature regulation and decreased overall body mass. Hypothermia leads to prolongation of the duration of action of NMBDs.

In conclusion, **decreased cardiac output leads to a delayed onset of action in the elderly. Also, reductions in clearance and hepatic metabolism as well as changes in volume of distribution and thermal regulation lead to a prolonged duration of action. Therefore, mildly reduced dosing must be adjusted as appropriate for age, especially in elderly patients over the age of 75**.