Monitored Anaesthesia Care in the Elderly
Guidelines and Recommendations

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As the number of elderly patients undergoing surgery continues to rise, it is important to consider anaesthetic options that minimize physiological stress in these patients. Monitored anaesthesia care (MAC), or sedation and monitoring during surgery, is an attractive option for certain common procedures. However, those administering MAC must consider the normal decline in functional reserve in patients aged >70 years. This includes loss of normal compensation for the stress of hypovolaemia, decreased peripheral vascular resistance, altered mental status and reduced response to hypoxia and hypercarbia associated with the perioperative and sedated state in this population. In addition, vigilance is necessary to identify co-morbid states, which increase in incidence with age and often present atypically. Elderly patients have increased sensitivity to all sedatives and opioids (doubled by age 80 years, quadrupled by age 90 years with benzodiazepines). As a result of changes in body composition, as well as senescence of renal and hepatic function, the time to onset and offset of even short-acting sedatives will be prolonged. There is also extreme variability in the response to sedatives among these patients.

Anaesthetic dosing should be in smaller increments in the elderly, boluses reduced by half and infusions reduced by as much as two-thirds. Caution must be exercised through full monitoring of intra-operative and postoperative mental status, oxygenation and perfusion states. Pain is best treated using smaller doses in a multimodal regimen, the aim being to reduce adverse effects while ensuring adequate pain relief. In this way, a huge range of procedures can be safely performed in our aging population with expectations for a full and early return to baseline functional status.

As life expectancy increases, the number of elderly patients undergoing surgical procedures continues to increase. Approximately 15% of the Western population and about 25% of surgical patients are currently aged >65 years. By the year 2030, one in five Americans will be aged >65 years, and 21% of them will undergo surgery each year. The fastest growing sector of the elderly population is the subgroup aged >85 years. While the incidence of intra-operative adverse events (primarily cardio-
vascular) increases linearly with age, the available evidence indicates that age itself is not the primary predictor of perioperative mortality; rather, the existence of co-morbid states, the site of surgery and the setting of an emergency procedure are the important factors that predict outcome.

Monitored anaesthesia care (MAC) is care given by an anaesthesiologist during surgery and consists of monitoring with or without sedation. It is often a supplement to local anaesthesia provided by the surgeon. In this setting, the patient breathes spontaneously and is arousable, comfortable and cooperative. MAC is an alternative to general or regional anaesthesia (spinal, epidural or major nerve block). Studies show cognitive decline in elderly patients after general anaesthesia, which may suggest that MAC would be a better choice for the elderly. A recent study that specifically addressed the correlation between anaesthesia management and 1-year mortality rate after major surgery with general anaesthesia found that the cumulative time of deep hypnosis as well as intra-operative hypotension were independent predictors of increased mortality. Thus, the primary goal of MAC is to minimize the effects of anaesthesia on cardiovascular, pulmonary and neurological systems in the surgical patient while maintaining an unaltered functional status.

There are also economic considerations that encourage surgical procedures to be performed using local anaesthesia with MAC, where feasible. Procedures may be located in a day surgery area of a hospital, outpatient surgical centres or at a doctor’s office. Since many of these procedures are currently being performed on patients aged >65 years using MAC, there is a need to assess specific risk factors and offer recommendations for the safe administration of MAC in the elderly population.

In this article we review specific age-related issues regarding perioperative care of the elderly. These include the physiological and pharmacological changes associated with senescence, and the impact of co-existing diseases in the elderly when tailoring anaesthetic techniques to such patients. We also review anaesthetic medications and monitoring requirements for the safe performance of MAC in the elderly. Finally, we discuss potential complications, management of postoperative pain and readiness for discharge after the administration of MAC in elderly patients.

1. Age-Related Physiological Changes in the Elderly

1.1 Changes in Organ Systems

The process of natural aging causes a progressive decline in the structure and physiological function of all human beings. This process is probably caused by progressive damage by reactive free oxygen radicals to DNA and protein structure and is associated with decreased function and reserve even in ‘healthy’ people aged >70 years. In addition to natural decline, the incidence of co-existing disease increases with age.

1.1.1 Cardiac System

Aging brings about increased fibrosis of the myocardium. There is preserved systolic function but impaired diastolic filling of the left ventricle. Diastolic filling is more dependent on atrial contraction. Because the prevalence of atrial fibrillation increases with age (the condition affects approximately 5% of all patients aged >65 years), elderly patients often have further compromise of ventricular filling secondary to loss of atrial systole. Under stress, such as that occurring during MAC and surgery, the heart has a reduced chronotropic and inotropic response to catecholamines and limited maximal aerobic capacity. As a result, elderly patients are mostly dependent on preload to increase cardiac output during stress. Progressive ventricular hypertrophy develops in response to increased afterload. Ventricular hypertrophy increases both wall stress and myocardial oxygen demand and makes the ventricle more prone to ischaemia.

Although intrinsic contractility and resting cardiac output are unaltered with aging, the practical effect of ventricular hypertrophy and stiffening is that the heart has limited ability to adjust stroke volume. There is also an overall increase in left
atrial size with age that is thought to be secondary to the chronic effect of reduced left ventricular compliance. Degenerative changes of the conduction system can also lead to heart block.[9]

In addition to normal cardiovascular aging, the incidence of coronary heart disease over a 10-year follow-up of adults aged >65 years was 39.6 in men and 22.3 in women per 1000 person-years; the incidence of congestive heart failure increased 9% with each year over age 65.[10] Because normal physical activity declines and metabolic demands are reduced, cardiovascular disease is not always recognized in the elderly and the clinical manifestations are frequently atypical.[11] A history of cardiac disease, cardiac risk factors, reduced exercise tolerance and type of surgery are predictors of perioperative risk. Currently, guidelines for preoperative risk stratification and preparation are similar, whether the procedure is performed under MAC, regional or general anaesthesia.

1.1.2 Pulmonary Function

The pulmonary system also undergoes age-related changes in both mechanics and control mechanisms, independently of co-morbid disease processes. With aging, the thorax becomes stiffer.[12] This may not be evident in the sedentary patient, but reduced chest wall compliance increases the work of breathing and reduces maximal minute ventilation.[13] Because of a decrease in elastic lung recoil, the closing volume increases to such a degree that by age 65 years it exceeds functional residual capacity.[14] Inspiratory and expiratory functional reserves decrease with aging, normal ciliary function is decreased and cough is reduced. Finally, matching of ventilation and perfusion is compromised.[15] The latter process increases the alveolar-arterial oxygen gradient and decreases resting oxygen partial pressure.

Sensation and the motor function required for swallowing are diminished. Airway protective reflexes are weaker in the aged, which increases the risk of pulmonary aspiration of gastric content. This is a particular concern when the level of consciousness is depressed by sedatives, as often happens in patients under MAC. There is also a decreased response to hypoxaemia and hypercarbia.[16] In the setting of sedation with opioids or benzodiazepines, there are more episodes of apnoea or periodic breathing. Oxygen supplementation and monitoring are therefore essential.

The risk of perioperative mortality in patients with postoperative pneumonia is 20%.[17] The odds ratio is 1.56 for patients of all ages undergoing general anaesthesia compared with MAC or spinal anaesthesia, and 5.63 for patients aged ≥80 years compared with patients aged <50 years. History of impaired sensorium or permanent neurological deficit and dependent functional status are additional risk factors.

The risk of other pulmonary complications (bronchospasm, respiratory failure, atelectasis or exacerbation of underlying chronic lung disease) is apparently unrelated to age. It could be expected that MAC, when applicable, would enable early detection of exacerbation of pulmonary conditions in patients with chronic lung disease. Importantly, arterial blood gases are less reliable predictors of pulmonary risk in such individuals than clinical findings and exercise tolerance.

1.1.3 Hepatic Function

Liver blood flow falls by about 35% between young adulthood and old age, and liver size by about 25–50%. Serum and biliary cholesterol appear to increase, predisposing elderly people to coronary disease and gallstones. All of these points to an age-related decrease in biotransformation of many anaesthetics and sedatives, especially those with large first-pass effects. Most intravenous anaesthetics are metabolized primarily by the liver (with the prominent exception of remifentanil). Hepatic blood flow may be further compromised during sedation if blood pressure (BP) falls because of the sedatives administered, or if there is significant blood loss. Ordinarily, liver function tests are intact but the liver functional reserve is low.[18,19]

1.1.4 Renal Function

Anatomic abnormalities in the aging kidney include a decrease in kidney size, glomerular sclerosis, altered tubular structure and an altered pattern of vascular flow. These anatomic abnormalities are
associated with renal functional abnormalities, including decreased renal blood flow and glomerular filtration rate (GFR) [figure 1]. Altered renal tubular function, including impaired handling of water, sodium, acid and glucose, may also be present. Impaired endocrine function, manifested by changes in the renin-angiotensin system, vitamin D metabolism and antidiuretic hormone responsiveness, is also present. It has been argued that hypertension, which is frequently encountered in the elderly, is an important factor in the development and progression of renal insufficiency in the elderly.\(^\text{20}\)

The water content of the body declines with age. Fluid intake is frequently reduced in senescence because of a reduced sensation of thirst. The combined effects of water depletion, reduced baroreceptor sensitivity and reduced cardiac reserve increase the risk for orthostatic hypotension in the elderly.\(^\text{22}\) This is partly responsible for the increased frequency of perioperative cardiovascular instability observed in these patients.

### 1.1.5 Nervous System

Independently of any co-morbid process, both the central and peripheral nervous systems are affected by aging.\(^\text{23}\) Loss of cortical grey matter begins in middle age, resulting in cerebral atrophy.\(^\text{24}\) At the level of the neuron, the complexity of neuronal connections decreases, the synthesis of neurotransmitters decreases and the enzymes responsible for their postsynaptic degradation increase. While cerebral metabolism, blood flow and autoregulation generally remain intact, neuronal loss and the deficiency of neurotransmitters limit the ability of the older brain to integrate multiple neural inputs. Functionally, spinal cord reflexes change and proprioception is reduced. There are also important decreases in hypoxic and hypercarbic drive.\(^\text{25}\) Declines in visual and auditory function further complicate the ability of the nervous system to acquire and process information. This combination of changes can limit the ability of the older patient to understand and process information during MAC and in the perioperative period. These changes are probably important contributors to drug toxicity and postoperative delirium.

Aging is also associated with neuronal loss in the autonomic nervous system. Both sympathetic and parasympathetic ganglia lose neurons, and fibrosis of peripheral sympathetic neurons occurs. This peripheral neuronal adrenergic loss is associated with impairment of cardiovascular reflexes.\(^\text{26}\)

Numerous neurotransmitter systems are altered with aging. For example, dopamine uptake sites, transporters and levels are reduced. Cortical cholinergic activity also decreases, a finding of particular significance since failure of cholinergic neurotransmission is a central feature of Alzheimer’s disease.\(^\text{27}\) Slow reaction time and cognitive processing manifest cognitive impairment. There is an inverse relationship between age and speed of motor performance. The more complex the task, the slower the response. This is caused by slow central processing of information. There is a deterioration in ‘fluid’ intelligence, i.e. the ability to respond to novel environmental events. Short-term memory is also affected.\(^\text{28}\) Cognitive and sensory difficulties frequently jeopardize obtaining informed consent from frail elderly patients. Dementia, depression, hearing difficulties and prior stroke may all interfere with the ability to make independent decisions.\(^\text{29}\) They might also hamper communication during MAC.

### 1.1.6 Endocrine System

Impairment of glucose tolerance is a common feature of human aging. Diabetes mellitus is present in 20.9% of people aged >65 years in the US.\(^\text{30}\) In addition, a state of glucose intolerance (fasting glu-
cose between 100 and 125 mg/dL or blood glucose between 140 and 200 mg/dL after a 2-hour glucose tolerance test) is present in 40% of people aged between 40 and 74 years, and is probably more common in people aged >75 years. With age, there are changes in body composition, including a decline in fat-free mass and a decline in physical activity. There is a reduction in insulin sensitivity in muscle and fat and initially a hyperinsulin state, which tapers off as pancreatic β cells lose function. Thus, with age, there is reduced sensitivity and availability of insulin. Presentation of diabetes is atypical in the elderly, leading to a delay in diagnosis, treatment and occurrence of severe secondary vascular affects. Mortality risk is also high in hospitalized elderly patients with diabetes. Diagnosis is based on the same fasting and post-glucose load levels, but treatment in the elderly should be targeted to a higher blood glucose level because of the increased incidence of hypoglycaemic events in elderly patients with diabetes treated with oral anti-hyperglycaemic agents.

As part of normal aging, secretion of thyrotropin-releasing hormone from the hypothalamus is reduced; however, thyroid-stimulating hormone (TSH) levels remain normal or in the low normal range, levothyroxine sodium (T4) levels are normal, and liothyronine (T3) levels may be only slightly low. There is some evidence for decreased tissue sensitivity (but not pituitary sensitivity) to thyroid hormone. Thyroid dysfunction is more common in the elderly. Hypothyroidism, defined as TSH >10 U/mL, is present in 5% of patients aged >60 years, compared with 0.1% of patients aged <22 years. Its presentation is atypical and symptoms (tiredness, weakness, loss of appetite, etc.) are often misinterpreted as being related to advanced age or other comorbidities rather than to a correctable thyroid dysfunction. Hypothyroidism is associated with a worse cardiovascular status. Older patients require less thyroid replacement therapy than their younger counterparts. Urgent surgery should not be postponed because of mild or moderate hypothyroidism; however, the anaesthetic doses used in such cases should take into account the further reduction in metabolic rate. There is no consensus on thyroid function screening recommendations. In addition to thyroid disease, poor health status is associated with lower T3 levels (secondary to reduction in conversion of T4 to T3), increased reverse T3 and decreased TSH levels as part of the effect of chronic illness on the hypothalamic-pituitary axis. Serum replacement is not helpful in these patients. Hyperthyroidism in the elderly is often subclinical and presents as 'apathetic' hyperthyroidism. A high index of suspicion is required as treatment can improve cognitive status significantly.

1.2 Pharmacodynamics

Aging often results in different responses to the same effect-site drug concentration when compared with younger individuals. By using continuous EEG analysis during incremental dosing of sedatives, it is possible to correlate the blood concentration of a drug with its effect on the EEG in volunteers of different ages. In this way it has been demonstrated that the brains of elderly people are more sensitive to midazolam, opioids and propofol. In addition, the sensitivity of β-adrenoceptors, especially in the heart, to agonists and antagonists, is reduced.

1.3 Pharmacokinetics

Changes in body composition with age can affect drug disposition in different ways. Increases in body fat and decreases in lean body mass and total body water content, as well as relative changes in protein constituents, affect drug pharmacokinetics. Most sedatives follow a multi-compartment pharmacokinetic model. With aging, the central compartment is smaller because of decreased body water and the peak concentration after a bolus dose might be higher than expected. On the other hand, because fatty stores are increased, there might be prolonged drug effects. With aging, the circulatory level of albumin decreases while that of α1-acid glycoprotein increases. Thus, medications that bind to albumin, e.g. diazepam, have an increased circulating free fraction and a smaller initial dose is needed; clearance may be increased. On the other hand,
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Fig. 2. Changes in pharmacokinetics with age. Half-life (t½) and both clearance and maintenance dosing rate of a drug vary with age. The values are calculated from data for creatinine. t½ is expressed as a fraction of the average value for a typical 55-year-old adult patient; the dosage regimen is calculated assuming that the desired average plateau unbound concentration of the drug (that is then eliminated entirely by renal excretion with a clearance equal to the glomerular filtration rate) remains constant throughout life. Elimination is slow in the neonate because of poor renal function but improves rapidly thereafter. Although bodyweight and, therefore, volume of distribution change only slightly beyond 30 years of age, t½ is longer in the aged, because renal function and, therefore, clearance progressively diminish. By 95 years of age, t½ is twice the typical adult value (reproduced from Rowland and Tozer with permission).

medications that bind to \( \alpha_1 \)-acid glycoprotein have a reduced free fraction causing reduced potency as well as reduced clearance. In addition, qualitative changes may occur in circulating proteins, thereby reducing the binding effectiveness of these proteins. Co-administered drugs may interfere with the ability of anaesthetic agents to bind to these proteins, leading to exaggerated clinical effects of the anaesthetic drugs. Decreased hepatic mass, hepatic blood flow and microsomal demethylation pathway activity will result in greater bioavailability of agents with high hepatic clearance, e.g. alfentanil and propofol. An age-related reduction in creatinine clearance delays the offset of certain medications and their active metabolites (figure 2). This is seen after prolonged infusions of midazolam in patients with reduced renal function.[34]

In addition, because of the huge range in baseline health status, there is great variability and unpredictability in the response of an elderly patient to any given dose.[21] Medications must, therefore, be given in small increments and titrated to effect. Importantly, time to peak effect is delayed and ample time must be allowed to elapse before repeat dosing. This will avoid unnecessary over-sedation as well as exaggerated, undesirable adverse effects, which are known to be more frequent in this population.

In summary, when dosing elderly individuals for sedation, it is important to consider the following five factors. First, changes in body composition affect drug volume of distribution and peak concentration. Secondly, because there is often a delay between delivery of a medication and its arrival at the effect site, a delay in onset of effect should be anticipated. Thirdly, because clearance may be reduced, infusion rates should be reduced to maintain the desired peak concentration, and a delay in the offset of effect should be anticipated. Fourthly, there is a profound increase in sensitivity to all sedatives, hypnotics and opioids in elderly patients (octogenarians are twice as sensitive to opioids, benzodiazepines and propofol) and reduced reserve for compensating for respiratory and cardiovascular adverse effects. Fifthly, variability of response to drugs increases with age. Finally, as an example, in patients aged 90 years, midazolam dose should be reduced by 75% for a colonoscopy and a delay in the offset of effect should be expected[39] (table I).
### Table I. Commonly used intravenous (IV) drugs during monitored anaesthesia care

<table>
<thead>
<tr>
<th>Sedatives/anxiolytics/hypnotics</th>
<th>Drugs</th>
<th>Bolus IV dose</th>
<th>Infusion</th>
<th>Properties</th>
<th>Adverse effects</th>
<th>Advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midazolam</td>
<td>0.5-mg increments up to 2 mg</td>
<td>Not recommended</td>
<td>GABA agonist</td>
<td>Respiratory depression (2-mg dose lowers SaO2 to &lt;94% in 90% of elderly)</td>
<td>Amnesia, anxiolysis, sedation, haemodynamic stability</td>
<td></td>
</tr>
<tr>
<td>Methohexital</td>
<td>12–20 mg</td>
<td>20–60 μg/kg/min</td>
<td>Barbiturate</td>
<td>Respiratory depression, hypotension</td>
<td>Rapid onset/offset</td>
<td></td>
</tr>
<tr>
<td>Propofol</td>
<td>0.5–0.8 mg/kg initial bolus</td>
<td>0.5–2 mg/kg/h</td>
<td>Hypnosedative</td>
<td>Sympatholysis, decreases BP &lt; propofol but &gt; midazolam</td>
<td>Rapid onset/offset; anti-emetic</td>
<td></td>
</tr>
<tr>
<td>Dexamethasone</td>
<td>1 μg/kg IV over 10 min</td>
<td>0.2–0.7 μg/kg/h</td>
<td>Selective α2-&lt;br&gt;adrenoceptor &lt;br&gt;agonist</td>
<td>Onset/offset &gt;&gt; midazolam/propofol</td>
<td>Sedation preserves psychomotor response</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Half dose if given with midazolam</td>
<td></td>
<td>Half-life = 2 h</td>
<td>Safe haemodynamic profile even at very high doses</td>
<td>No central respiratory depression</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Not recommended for day-surgery patients</td>
<td>Useful for neurosurgery and major vascular and minor surgery under local/ regional anaesthesia; lowers IOP</td>
<td></td>
</tr>
<tr>
<td>Sedatives/analgesics</td>
<td>Ketamine</td>
<td>20–30 mg</td>
<td>Not recommended</td>
<td>Analgesic/sedative</td>
<td>Bronchorrhea</td>
<td>Sustained BP, bronchodilator, useful for chronic &gt; acute pain patients</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.25 mg/kg with propofol</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analgesics</td>
<td>Remifentanil</td>
<td>Half standard young adult dose (12.5–25 μg)</td>
<td>One-third standard young adult dose (0.025–0.05 μg/kg/min)</td>
<td>Opioid</td>
<td>Sedation, analgesia, depresses respiration &gt; propofol/fentanyl</td>
<td>Minimal renal and hepatic metabolism results in prompt awakening</td>
</tr>
<tr>
<td></td>
<td>Fentanyl</td>
<td>10–25 μg</td>
<td>20–40 μg/h</td>
<td>Opioid</td>
<td>Sedation, analgesia, depresses respiration &gt; morphine</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Alfentanil</td>
<td>0.25–0.50 mg</td>
<td>0.1–0.25 μg/kg/min</td>
<td>Opioid</td>
<td>Sedation, analgesia, depresses respiration &gt; morphine but = fentanyl</td>
<td>Quick awakening</td>
</tr>
<tr>
<td></td>
<td>Tramadol</td>
<td>50–75 mg</td>
<td>Slow infusion</td>
<td>Weak opioid and SSRI</td>
<td>PONV</td>
<td>Lacks opioid/NSAID adverse effects on respiration/GI tract/kidney</td>
</tr>
</tbody>
</table>

Continued next page
2. Patient Preparation

Clinicians should provide both patients and their attendants with written instructions on preoperative fasting, medications, anaesthesia and postoperative care.

2.1 Preoperative Fasting

Pulmonary aspiration of gastric contents is considered to be a potential life-threatening complication of anaesthesia. Patients should fast prior to anaesthesia to allow sufficient time for gastric emptying. Long-term prospective studies and retrospective reviews have shown that the incidence of significant clinical aspiration is 1.4–6/100 000 anaesthetics for elective general surgery. No data are available as to the risk and incidence of pulmonary aspiration associated with MAC. Risk factors for aspiration under general anaesthesia include a high American Society of Anesthesiologists (ASA) physical status score, difficult airway management, increased gastric volume and acidity, increased intra-abdominal pressure, gastro-oesophageal reflux, impaired consciousness and extreme age. The recommended fasting period is 6 hours after solid food, including milk, and 2 hours after clear liquids. When discussing fasting with the patient, it is important to be very specific as to what are ‘clear liquids’.

2.2 Long-Term Medications

Patients must take necessary medications such as antihypertensive, cardiac, antiepileptic and asthma medications with sips of water on the day of surgery. People with diabetes should continue taking oral antihyperglycaemic agents until the evening before surgery. Blood glucose levels must be checked and insulin should be administered on the morning prior to surgery. Aspirin (acetylsalicylic acid) should be stopped 1 week before surgery if the dose is >100 mg/day. Anticoagulation with coumadin (warfarin) should be managed perioperatively according to the risk to the patient for thromboembolism and operative bleeding. If the patient is at high risk of thromboembolism (e.g. had a venous embolic event within 3 months, has a mechanical cardiac mitral
valve), coumadin should be stopped 4 days before surgery and intravenous heparin or low-molecular-weight heparin (LMWH) started 2 days before surgery. Intravenous heparin should be stopped 5 hours before surgery and LMWH 12 hours before surgery. Coumadin and bridging anticoagulant should be resumed 12 hours after surgery, as long as there is no postoperative active bleeding. If the patient is at low risk for thromboembolism (>3 months after acute venous embolic event or atrial fibrillation without prior stroke), coumadin should be stopped 4 days before surgery and resumed after surgery, while also using LMWH or subcutaneous heparin starting 12 hours postoperatively until oral anticoagulation reaches the therapeutic range. If the surgical risk of bleeding is low (e.g. gynaecological or orthopaedic procedures), coumadin may be continued at a lower than usual dose, starting 4 days preoperatively, and aiming for an international normalized ratio of 1.5–1.8.1

Percutaneous coronary revascularization with stents requires prophylaxis with dual antiplatelet therapy: aspirin plus clopidogrel. Because periprocedural stent thrombosis can be catastrophic, it is best to delay surgery for 6–8 weeks after placement of a bare metal stent and 12 months after placement of a drug-eluting stent. If surgery cannot be delayed and there is significant risk of surgical bleeding, clopidogrel should be stopped 5–10 days before surgery, a bridging short-acting antiplatelet agent should be used and clopidogrel should be restarted as soon as possible after surgery.149

The risks of withdrawal seem to justify continuation of selective serotonin reuptake inhibitors in patients who are mentally stable.50 Antidepressants are often used by patients with neurodegenerative disorders to help states of depressed mood, appetite loss, insomnia, fatigue, irritability and agitation. Tricyclic antidepressants may cause orthostatic hypotension and cardiac arrhythmias, especially in large doses and during anaesthesia. Benzodiazepines are the most frequently prescribed psychotropic drugs in the elderly; however, they can cause confusion, sedation and ataxia, and are associated with an increased risk of falls and bone fractures. Antipsychotics have been shown to induce parkinsonian symptoms in over 30% of all patients.51 The incidence increases with older age, pre-existing extrapyramidal signs and with use of a drug such as haloperidol.

Patients taking medications for Parkinson’s disease are very difficult to monitor as the adverse effects of the drugs, such as lethergy, decreased cognitive function and dyskinesia, are similar to the manifestations of the disease itself.51

Caution is needed when using NSAIDs in patients aged >70 years because of possible adverse effects (higher incidence of hyperkalaemia, renal failure and gastrointestinal bleeding with a high mortality rate), especially in patients with pre-existing renal failure.52

2.3 Preoperative Testing

Preoperative laboratory tests are performed as part of the preoperative assessment regardless of the type of anaesthesia. Current recommendations are that healthy elderly patients (aged >60 years) should be routinely tested for haemoglobin and haematocrit, glucose, blood urea nitrogen and creatinine, 12-lead ECG and chest radiograph (where needed) abnormalities.125 ASA classification and surgical risk are independent predictors of in-hospital adverse postoperative outcomes. Selective testing, as indicated by history and physical examination (which will determine the degree of co-morbidity and risk), is indicated;55 such testing should include coagulation studies.

3. Patient-Specific Monitoring

Basic monitoring recommended by the ASA for procedures performed under MAC include ECG, BP, respiratory rate and pulse oximetry. However, the extent of monitoring should consider the patient’s condition and degree of invasiveness of the surgical procedure and should not be minimized simply because the patient is ‘awake’. There is the added value of an ‘awake’ patient’s subjective feedback of distress. This added value depends on the degree of wakefulness, cooperation and reliability of the patient’s communication.56
Importantly, qualified anaesthesia personnel must be present in the room throughout the conduct of all MAC. During all anaesthetics, the patient's oxygenation, ventilation and circulation should be continually evaluated. Pulse oximetry must be used to ensure adequate oxygenation. Assessment of qualitative clinical signs of ventilation, such as chest excursion, auscultation of breath sounds or the presence of exhaled carbon dioxide, is necessary in all cases where deep sedation is used. The ASA practice guidelines for sedation and analgesia by non-anaesthesiologists further recommends following the patient's response to verbal contact.\textsuperscript{[57]}

Intra-operatively, all patients should be connected to an ECG for continuous assessment of rate, rhythm and ST analysis. Use of two leads, typically leads II and V5, of an ECG, has been shown to have a high sensitivity for detection of myocardial ischaemia. Circulatory evaluation by at least one of the following is also essential: palpation of the pulse, monitoring of a tracing of intra-arterial pressure or plethysmography-associated oximetry.\textsuperscript{[57]}

4. Assessment of the Level of Sedation

Sedation is currently assessed by two scoring systems:

1. The Ramsay scale assigns a score of 1–6, based on the clinical assessment of the level of sedation, evaluating response to sound, verbal commands or tactile stimulation by the anaesthetist. Scores 1–3 apply to arousable patients: 1 = anxious, agitated, restless; 2 = awake, but cooperative, tranquil, oriented; 3 = responds to verbal commands only. Scores 4–6 apply to sleeping patients and are graded according to the response to a loud noise or a glabellar tap: 4 = brisk response; 5 = sluggish response; 6 = no response.\textsuperscript{[58,59]}

2. The sedation visual analogue scale (VAS) is a simple method of assessment in which a stimulated patient is asked how sedated he/she feels on a scale from 1 to 10. Patients differ considerably in their ability to reliably self-rate their sedation level using the VAS.\textsuperscript{[60]}

Sudden meaningful depression of vital signs, such as slow respiratory rate, low heart rate or BP, are clinical signals of sedation-induced central depression that warrant quick medical and/or pharmacological responses.

5. Specific Agents, Doses and Related Risks for Medications Used for Monitored Anaesthesia Care (MAC)

The spectrum of medication used during MAC includes sedative/hypnotic/anxiolytic drugs to minimize the stress associated with the milieu of the operating room, drugs with amnesic properties to reduce recall of intra-operative events and analgesic medication to minimize patient discomfort from surgery (table I). Single- or multi-drug protocols must be tailored individually to the patient.

5.1 Sedatives/Anxiolytics/Hypnotics

5.1.1 Benzodiazepines

Benzodiazepines are commonly employed because of their anxiolytic and amnesic effects. Among them, midazolam is a better alternative to diazepam because of its short half-life; it is also water soluble and causes no pain on injection.\textsuperscript{[61]}

Midazolam is associated with good intra-operative amnesia and sedation compared with propofol, but is also associated with a slower recovery time of psychomotor function.\textsuperscript{[62]} Its onset of action is between 2 and 2.5 minutes. Midazolam is metabolized by the liver cytochrome P450 system to active hydroxymidazolam and inactive metabolites, which are then secreted in the urine. Its half-life in adult volunteers is between 1.5 and 3.5 hours, but this can be prolonged after continuous infusions in very ill patients and in patients with decreased renal function.\textsuperscript{[63]} Small intravenous repetitive doses are recommended to minimize deep/prolonged sedation. Of note, elderly patients are extremely sensitive to the respiratory and cardiovascular effects of intravenous midazolam.\textsuperscript{[64]} On rare occasions (<1%), patients treated with midazolam can develop paradoxical reactions characterized by restlessness and agitation. This reaction can be reversed by small doses of flumazenil (0.1–0.5 mg),\textsuperscript{[65,66]} without reversing the
amnesic and sedative effects of the benzodiazepine receptor agonist.

5.1.2 Barbiturates

Barbiturates have been used in the past for sedation during MAC. The most commonly used intravenous barbiturates were methohexital and thiopental sodium. Methohexital 2.5 mg in a bolus is equivalent to propofol 5 mg for patient-controlled sedation in the elderly. Methohexital provides an excellent steady level of intra-operative sedation when administered via an infusion pump. Of note, propofol has now fully replaced use of barbiturates in MAC.

5.1.3 Propofol

Propofol is a fast-acting intravenous sedative-hypnotic agent that rapidly and reliably reduces the level of consciousness. It is also associated with a quick and smooth recovery; adult patients typically regain consciousness within 8 minutes from cessation of administration of propofol. The drug is safely administered in patients with kidney and liver failure and may be useful in patients who have developed tolerance to benzodiazepines. Careful titration is mandatory as respiratory depression is always a potential danger because of significant decreases in tidal and minute volumes; there is also a risk of apnoea at higher than sedative doses and reductions in both hypercarbic and hypoxic ventilatory responses can occur.

The cardiovascular effects of bradycardia, decreased systemic vascular resistance and reduced cardiac output are mildly significant in patients receiving low (sedative dose) rates of propofol infusions (table II). Time to peak effect is slightly prolonged because of the pharmacokinetics of propofol in the elderly. Recovery, although rapid, after discontinuation of an infusion is significantly longer in elderly patients secondary to their increased sensitivity to propofol. The blood propofol concentration required for 50% of patients aged 25 years to lose consciousness is twice that of patients aged 75 years (figure 3). The effect of propofol on systolic BP is also exaggerated in the elderly. A small dose of midazolam increases sedation, amnesia and anxiolysis when administered immediately prior to the propofol infusion as part of sedation technique (table I). Some studies suggest that propofol (20 mg) possesses anti-emetic properties, with a shorter post-anaesthesia care unit stay and a greater degree of patient satisfaction. Pain on injection is the most common adverse effect of propofol, followed by excitatory phenomena and involuntary movements. Pain on injection can be minimized by pre-mixture of lidocaine (lignocaine) with the propofol solution. Table II shows the age-related frequency of unwanted adverse effects in propofol-sedated patients undergoing endoscopic procedures.

<table>
<thead>
<tr>
<th>Adverse effect</th>
<th>Cohort</th>
<th>p-Values vs &lt;70 y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergency interventions^a</td>
<td>age &lt;70 y (n = 2534)</td>
<td>0.3</td>
</tr>
<tr>
<td>IV atropine administration</td>
<td>age 70–85 y (n = 1167)</td>
<td>0.3</td>
</tr>
<tr>
<td>SaO2 &lt;90%^b</td>
<td>age &gt;85 y (n = 318)</td>
<td>0.3</td>
</tr>
<tr>
<td>SaO2 decreased by &gt;5%^b</td>
<td></td>
<td>0.3</td>
</tr>
<tr>
<td>MAP decreased by &gt;25%</td>
<td></td>
<td>0.3</td>
</tr>
<tr>
<td>SBP decreased to &lt;90 mmHg</td>
<td></td>
<td>0.3</td>
</tr>
<tr>
<td>HR decreased by &gt;20%</td>
<td></td>
<td>0.3</td>
</tr>
<tr>
<td>HR decreased to &lt;50 bpm</td>
<td></td>
<td>0.3</td>
</tr>
</tbody>
</table>

^a Includes Esmarch's manoeuvre, mask ventilation and/or placement of a nasopharyngeal airway.
^b Oxygen 2 L/min or more was continuously administered via a nasal probe.

bp = beats per minute; HR = heart rate; IV = intravenous; MAP = mean arterial pressure; NS = not significant; SaO2 = arterial blood oxygen saturation; SBP = systolic blood pressure.

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5.1.4 Dexmedetomidine

Dexmedetomidine is a potent and highly selective $\alpha_2$-adrenoceptor agonist with hypnosedative and anaesthetic-sparing properties. $^{79,80}$ It may be useful for elderly patients undergoing cataract surgery under regional anaesthesia because it reduces intra-ocular pressure perioperatively, $^{81}$ as well as for vascular surgery (carotid endarterectomy, peripheral revascularization), neurosurgery (awake craniotomy), general surgery, plastic surgery and to supplement regional or local anaesthesia. Dexmedetomidine decreases anxiety, sympathoadrenal response and postoperative opioid analgesic requirements. $^{80,82}$

5.2 Analgesics

Opioids can be used to supplement propofol and local anaesthetics but might produce respiratory depression and a longer time-to-home readiness. $^{83,84}$

5.2.1 Remifentanil

Remifentanil is a highly potent opioid with a rapid onset of effect and a short duration of action due to its rapid hydrolysis by esterases in blood and tissues. $^{85}$ Its terminal half-life in adults ranges from 10 to 21 minutes. The rapid onset and short duration of action of remifentanil make it well suited for titration of dose (by changing infusion rate) to the desired effect. Although remifentanil can produce opioid-related adverse effects, its rapid elimination reduces the duration of these undesirable effects. $^{85}$

An important consideration arising from its rapid clearance is the necessity for providing postoperative pain relief. In the elderly, the peak concentration of remifentanil is similar to that of younger individuals after an initial bolus, but takes slightly longer to be reached because of slower equilibration between blood and effect-site concentrations. On the other hand, because of increased sensitivity to the sedative effects of the drug in the elderly (approximately double by EEG modelling), only half an adult bolus should be given. Since clearance of remifentanil in the elderly is 66% of that in younger people and the increased sensitivity of the elderly to the drug means that only half the usual amount needs to be administered, maintenance infusions should be run at about one-third the rate used in younger individuals. $^{86}$

In younger adults, remifentanil provides comparable intra-operative conditions to propofol sedation; however, it is associated with greater respiratory depression, more episodes of desaturation and longer time-to-home readiness. $^{83,86}$ A study of sedation of elderly patients (with significant co-morbid disease) during carotid endarterectomy under a cervical plexus block showed that despite similar sedative effects, remifentanil 0.05 $\mu$g/kg/min caused more adverse respiratory effects than propofol 1 mg/kg/hour. $^{87}$ Thus, propofol in elderly patients was found to be superior to remifentanil when used in the stated doses. Specific studies using other dosage regimens in this age group are lacking; nevertheless, remifentanil infusions should be used cautiously for sedation in the elderly.

5.2.2 Fentanyl and Alfentanil

Fentanyl, a synthetic opioid, is the most commonly employed opioid for MAC. Even in small boluses (25–50 $\mu$g), it can cause respiratory depression when combined with other sedatives. Recovery is significantly faster with alfentanil, another synthetic opioid, but young adult patients receiving alfentanil have a higher incidence of adverse events (chest wall rigidity, apnoea and laryngospasm) than
those receiving fentanyl. There are no consistent age-related changes in the pharmacokinetics of fentanyl or alfentanil. The decreased dose necessary for older patients represents the increased sensitivity of these patients to opioids. Along with the increased sensitivity to sedation, there is an increased incidence of respiratory depression. In a retrospective analysis of 8855 hospitalized patients who received opioids, patients aged 61–70 years had 2.8 times the risk, those aged 71–80 years had 5.4 times the risk and those aged >80 years had 8.7 times the risk of significant respiratory depression, as compared with adults aged ≤45 years. Conversely, the risk of nausea and vomiting decreased with age. Alfentanil given by a pharmacokinetic-based target controlled infusion for extracorporeal shock wave lithotripsy provided good analgesia with little sedation in a range of ages up to 77 years. Respiratory depression was uncommon, but supplementary oxygen was recommended.

5.2.3 Tramadol

Tramadol is a centrally acting analgesic lacking some of the adverse effects associated with other analgesic agents. Its dual mechanism of action includes a weak affinity for the μ-opioid receptor as well as inhibition of the neuronal reuptake of norepinephrine and serotonin.

Tramadol is rapidly absorbed and peak serum concentrations are attained about 2 hours after oral ingestion. It has an elimination half-life of 6.3 hours and is poorly bound (20%) to plasma proteins. Tramadol is indicated for the management of moderate to moderately severe pain and the usual dose is 50–100 mg every 4–6 hours, as needed. Slowly titrating the dose was effective in significantly reducing adverse effects, such as vomiting (reduced by 60%) and nausea (reduced by 38%), that may have led to discontinuation at higher initial doses. The maximum dosage of tramadol should not exceed 400 mg/day or 100 mg/dose, and patients aged >75 years should not receive more than 300 mg/day. In patients with a creatinine clearance <30 mL/min, the dosing interval should be increased to every 12 hours and the total dose should not exceed 200 mg/day. Patients with liver cirrhosis should not receive more than 50 mg of tramadol every 12 hours.

Overall, tramadol has demonstrated safety and efficacy and has a low abuse potential. A slow intravenous infusion of 50–75 mg before the end of surgery would provide good analgesia for 4–6 hours postoperatively. It augments analgesia when paracetamol (acetaminophen) is insufficient. Compared with traditional NSAIDs, tramadol lacks serious gastrointestinal or renal toxicity, which are major concerns in elderly patients. Even though the new cyclo-oxygenase (COX)-2 specific NSAIDs may demonstrate greater gastrointestinal safety than the older NSAIDs, tramadol has a superior renal safety profile. It may also be used to augment or replace NSAIDs and has an advantage over opioids because it is associated with less respiratory depression.

5.2.4 NSAIDs and Cyclo-Oxygenase-2 Inhibitors

NSAIDs non-selectively inhibit COX-1, leading to gastrointestinal and renal toxicity, and COX-2, leading to anti-inflammatory effects. NSAIDs are advantageous for perioperative management of pain because they do not produce opioid-related adverse effects and have a sparing effect on opioids both in terms of the amount required and adverse effects. They are one of the most commonly prescribed medications worldwide as they are effective for chronic and acute pain. For example, ketorolac, a potent parenterally active NSAID, has been used both as a sole analgesic and as a supplement to propofol sedation during local anaesthesia. Intravenous ketorolac 1 mg/kg up to a total dose of 60 mg (equipotent to 10 mg of morphine) is associated with a decreased incidence of pruritus, nausea and vomiting in the intra- and postoperative periods compared with opioids.

Selective COX-2 inhibitors appear to have anti-inflammatory and analgesic properties similar to those of conventional, non-selective NSAIDs, but cause less gastrointestinal toxicity. COX-2 inhibitors thus may be safer than non-selective NSAIDs for elderly patients, especially for those with a history of gastrointestinal ulcers, since gastroduodenal ulceration and bleeding is more common and has a higher mortality rate in patients aged >70 years.
Age was shown to be an independent predisposing factor for gastrointestinal bleeding, with the risk increasing significantly in individuals aged >65 years and increasing further in those aged >75 years. Indeed, bleeding incidence and mortality are distinctly higher in elderly patients. Importantly, rofecoxib was withdrawn from the market in September 2004 after preliminary results of the VIGOR (Vioxx Gastrointestinal Outcomes Research) trial showed five times the incidence of non-fatal myocardial infarctions in the rofecoxib group compared with the naproxen group. The risk of cardiovascular and cerebrovascular events with other COX-2 inhibitors, and with NSAIDs in general, is undergoing evaluation and their use for long postoperative periods or in patients with cardiovascular risk factors should be implemented cautiously.

In addition, there are many reports of hyperkalaemia and worsening renal failure in patients given NSAIDs, specifically when given in conjunction with ACE inhibitors, with or without diuretics. Patients who have a history of congestive heart failure (CHF) or, less commonly, hypertension, may be managed for these conditions with a combination of an ACE inhibitor (or an angiotensin II type 1 receptor antagonist [angiotensin receptor blocker]) and a diuretic. Such patients should not receive NSAIDs or COX inhibitors perioperatively. GFR is dependent on renal blood flow, afferent arteriolar vasodilation by prostaglandins and efferent arteriolar vasoconstriction by angiotensin. If both prostaglandins and angiotensin are inhibited (by NSAID analgesics or by long-term treatment with ACE inhibitors, respectively), renal blood flow must increase to maintain normal GFR. Patients who are volume depleted, have cardiomyopathy, renovascular disease or who are aged >75 years, lack the ability to make this compensation in renal blood flow necessary to maintain GFR, meaning renal failure will ensue. In addition, a case control study showed a significant increase in the risk of CHF in patients who recently (within the previous week) started NSAIDs other than aspirin. The risk was higher in patients with known cardiac disease, and was correlated to the dose of the NSAID given.

In summary, a recent review recommended against using NSAIDs in patients with GFR <30 mL/min, the US FDA has recommended not using prescription NSAIDs in patients who have had recent cardiac revascularization procedures, and it is prudent to use the lowest possible effective dose in elderly patients because all adverse effects are dose dependent.

5.3 Multimodal Analgesic Regimens

As a result of the shift to office or outpatient surgery, use of multimodal analgesic regimens, based on addition of non-opioid analgesics (e.g. local anaesthetics, NSAIDs, paracetamol, ketamine, a2-adrenoceptor agonists) to opioid analgesics, has increased. The opioid-sparing effects of these compounds reduce nausea, vomiting, constipation, urinary retention, respiratory depression, sedation and enhance postoperative pain relief.

5.4 Drug Antagonists

All types of drug antagonists should be used only and exclusively when reversal is mandatory and patients should remain under medical observation for twice the antagonist half-life in order to prevent unobserved relapse of the untoward reversed phenomenon.

5.4.1 Flumazenil

Flumazenil, a 1,4-imidazobenzodiazepine, is a specific benzodiazepine receptor antagonist that is indicated for use when the effect of a benzodiazepine must be quickly attenuated or terminated. Although flumazenil has a short elimination half-life of about 1 hour, an intravenous dose of up to 1 mg is sufficient to attain and maintain the desired level of consciousness for 2 hours after conscious-to-moderate sedation induced by benzodiazepines in adults. Small incremental doses of intravenous flumazenil 0.2 mg facilitate early recovery without adverse effects. Currently, the proven effective dose of flumazenil is up to 0.5 mg in the
elderly, and in this clinical setting, true re-sedation does not occur.

5.4.2 Naloxone
Naloxone is an opioid receptor antagonist with a rapid onset, short duration of effect and an elimination half-life of 1–1.5 hours. Naloxone 0.1–0.5 mg (maximum 2 mg) administered slowly restores adequate ventilation in patients who have received excessive doses of opioid analgesics.

6. Specific Procedures Performed Under MAC

A great variety of surgical procedures can be performed under MAC. A comprehensive, although not complete list, is provided by Smith and Taylor. Studies specifically addressing sedation protocols for selected procedures are reviewed in sections 6.1–6.5.

6.1 Oral or Dental Surgery
Pharmacological strategies used in outpatient dental settings must specifically consider preservation of protective upper airway reflexes. Intravenous midazolam/fentanyl sedation, with or without propofol, for dento-alveolar surgery provided stable intraoperative hemodynamics in elderly patients with coronary artery disease. NSAIDs could be administered to such patients at ~50% of the adult dose.

6.2 Ophthalmology
Patients undergoing eye surgery are a challenge to the anaesthesiologist because of the increased incidence of multiple systemic diseases in this patient group. Low-dose (0.15 mg) oral clonidine as pre-medication before intra-ocular surgery under retrobulbar anaesthesia appears to be comparable with use of dexmedetomidine 1 μg/kg over 10 minutes, followed by 0.1–0.7 μg/kg/hour intravenous infusion, or to intravenous midazolam 20 μg/kg followed by intravenous 0.5-mg boluses as required, for increasing patient comfort, offering haemodynamic stability and reducing BP response to perioperative stress. These investigators also concluded that dexmedetomidine alone was not suitable for sedation in patients undergoing cataract surgery because of accompanying cardiovascular depression and delayed recovery room discharge.

6.3 Plastic Surgery
In common with eye surgery, face-lifts and other plastic surgery on the face and neck limit the anaesthesiologist's access to the airway. Therefore, preservation of a patent airway and effective spontaneous ventilation are of utmost importance and necessitate careful drug titration to avoid deep sedation in this setting. Abeles and Segueira recommended using propofol and fentanyl in standard doses in patients aged between 25 and 65 years undergoing plastic surgeries. Doses must be adjusted in older individuals for conscious sedation.

6.4 Interventional Radiology and Gastroenterology Procedures
In some interventional radiology and gastroenterology procedures (e.g. gastroscopy), the anaesthesiologist and the interventionist compete for access to the airway. Avoidance of deep sedation is crucial under such circumstances to avoid hypoxaemia and airway obstruction. Administration of sedation and analgesia in interventional radiology and gastroenterology suites is often necessary during painful diagnostic and some intravenous therapeutic procedures. For preemptive analgesia, oral paracetamol or an NSAID can be administered followed by titration of small doses of midazolam alone or combined with an opioid (e.g. intravenousmidazolam 1-mg and fentanyl 25-μg boluses in incremental doses). Larger doses may be necessary during painful procedures such as hepatobiliary intervention or uterine fibroid embolization. Use of dexmedetomidine for colonoscopy is considered unacceptable because of adverse effects such as haemodynamic instability and longer than desired sedation effect.

For patients aged ≥65 years with co-existing cardiac or respiratory illness undergoing other types of procedure (e.g. drainage of intra-abdominal collection, nephrostomy insertion, trans-jugular hepatic biopsy or anterograde ureteric stent insertion),
Skehan and Malone[117] used fentanyl and midazolam that were administered in one to five steps (A, B, C, D, E) until the patient was drowsy and tranquil: A, fentanyl 1 μg/kg; B, midazolam 10–35 μg/kg; C, repeat dose in A; D, repeat half dose in B; and E, midazolam 1- to 2-mg boluses. Using this protocol, sedation, analgesia and amnesia were achieved without patients becoming apnoeic, but increased inspired oxygen concentration was necessary in part of the cohort.

6.5 Awake Vascular and Neurosurgical Procedures

Carotid endarterectomy (CEA) procedures are more frequently undertaken under MAC or local anaesthesia alone to allow monitoring for inadvertent brain ischaemia. The properties of dexmedetomidine that result in titratable sedation and sympathetic modulation suit such conditions and provide an acceptable alternative but provide no superiority to standard techniques for sedation during awake CEA performed under regional anaesthesia.

Anaesthetic techniques for awake craniotomy have been evolving over the years and include local anaesthesia with mild sedation. Neurosurgical procedures for tumour resection in eloquent brain areas (involving either speech or motor areas) and movement disorders are performed with the patient awake and cooperative so that neurological status can be monitored. Propofol sedation by infusion (1–1.5 mg/kg/hour) or in small boluses is delivered at the time of local anaesthesia infiltration and during placement of pins for the head holder. Both fentanyl by bolus and remifentanil by infusion have been used with equal success in conjunction with propofol in younger individuals.[118] In the study by Berkenstadt and Ram,[119] propofol 100 μg/kg/min and remifentanil 0.01 μg/kg/min for brain tumour removal was found to be safe. The most common complication was nausea and vomiting. Dexmedetomidine 0.5 μg/kg over 20 minutes followed by an infusion of 0.01–1 μg/kg/min has also been used successfully.[120]

7. Potential Complications Associated with MAC in the Elderly

Many elderly patients present to surgery with multiple pre-existing morbidities that may induce a higher risk of perioperative adverse events than is present in younger patients. Elevated ASA physical status, history of ventricular arrhythmia, angina, hypertension, previous myocardial infarction, severe bronchopulmonary disease, asthma, obesity and smoking are predictors for perioperative complications.[121] Cardiovascular events are the most frequent intra-operative events, which are more prevalent among the elderly. The incidence of intra-operative adverse events among elderly patients has been found to be higher in ear, nose and throat, dental, urological, orthopaedic and ophthalmic surgeries.[3] Intra-operative arterial pressure should be maintained within 20% of the best estimate of preoperative arterial pressure. In those patients in whom there is no contraindication, perioperative β-adrenergic blockade may be of value.[122]

7.1 Haemodynamic

Cardiovascular (risk factors: hypertension, ischaemic heart disease, low cardiopulmonary reserve and compensatory incapacity) events are the most frequent intra-operative events in patients aged >65 years.[123] Overdose was found to be the primary cause of anaesthesia-related cardiac arrest and death, mostly in patients with spinal anaesthesia.[124] These events may occur during or after MAC administration.

7.2 Airway and Respiratory

The potential for compromising the respiratory system results from depression of oesophageal and laryngeal reflexes, upper airway obstruction and depression of central hypercarbic and hypoxic ventilatory responses.[125] The patient must be carefully and continuously monitored for all of these conditions and maximum airway patency preserved in the elderly.
7.3 Neurological

7.3.1 Delirium

Depending on the type of surgery, 10–50% of older surgical patients develop acute confusion. The risk factors for emergence delirium in an elderly but otherwise healthy patient are use of preoperative benzodiazepines and surgery of long duration. Meperidine (pethidine) was consistently associated with an increased risk of delirium or cognitive decline in elderly patients, and other opioids can also generate such occurrences on occasion. Titrated bolus treatment of physostigmine 0.2 mg, up to a maximum of 2.5 mg, accompanied by close ECG monitoring, is a useful intervention for preventing this undesired event (Weinbroum AA, unpublished data).

7.3.2 Postoperative Cognitive Dysfunction

Postoperative cognitive dysfunction (POCD) is a decline in cognitive function for weeks or months after surgery. The subtle nature of this adverse event means neuropsychological testing is necessary for its detection. Interpretation of the literature on POCD is difficult because of numerous methodological limitations, particularly the different definitions of POCD used and the lack of data from control groups.

The risk of POCD increases with age and the complexity of surgery; there is a very low incidence associated with minor surgery. Regional anaesthesia does not seem to reduce the incidence of POCD.

7.4 Prolonged Hospital Stay

In a study assessing predictors of prolonged postoperative hospital stay after ambulatory surgery, 6301 individuals received MAC, 586 received local anaesthesia, 484 received regional anaesthesia and 157 patients received a long-term pain block. The mean age of patients receiving MAC was 67 ± 16 years. Factors associated with prolonged stay were length and type of surgery, undesired events such as excessive pain, nausea and vomiting, dizziness and cardiovascular events, and underlying conditions such as CHF.

7.5 Closed Claims-Related Data

Analysis of closed-claims reports associated with MAC showed a high severity of patient injury and a liability profile similar to claims associated with general anaesthesia, but a significantly smaller proportion of regional anaesthesia claims. The most common severe injury was severe respiratory depression resulting in death or brain damage in association with drugs used during sedation. Of a total of 121 claims for MAC patients, 26% were aged >70 years and 63% were female. Elective eye, head, neck and face surgeries and endoscopies were preponderant. Respiratory depression due to an absolute or relative overdose of sedative/hypnotic/analgesic agents was responsible for 25 MAC-related claims (21%). Propofol was used in half of the cases, either alone or in combination with a benzodiazepine and/or an opioid. A combination of a benzodiazepine and an opioid was used in seven cases of death or brain damage. Although most patients were monitored with pulse oximetry and 20% had both pulse oximetry and capnography in use at the time of the event, nearly half of the claims were judged as preventable by additional (or better) monitoring. Contributing factors to the serious incidents were distraction due to loud music in the operating room, inattention to monitors, monitor alarms off, poorly functioning pulse oximeters in sick patients, delay in resuscitation due to prone position (as during use of a magnetic resonance imaging scanner) and poor resuscitation technique.

8. Postoperative Pain Control in the Elderly after MAC

Given the expanding role of ambulatory surgery and the need to facilitate earlier hospital discharges, improving postoperative pain control (table III) has become an increasingly important issue for all anaesthesiologists. Inadequately treated pain is a major cause of unanticipated hospital admission after ambulatory surgery. Use of drug combinations may provide improved analgesia with fewer adverse
Monitored Anaesthesia Care in the Elderly

Table III. Analgesics commonly used for postoperative pain (reproduced with modifications from Zuccala et al., with permission)

<table>
<thead>
<tr>
<th>Drugs</th>
<th>Maximum daily dose (mg)</th>
<th>Route</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSAIDs or non-opioids</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paracetamol (acetaminophen)</td>
<td>1000–1500</td>
<td>PO/IV/PR</td>
<td>Not recommended in liver insufficiency</td>
</tr>
<tr>
<td>Dipyrone</td>
<td>1000–2000</td>
<td>PO/IV/IM</td>
<td>Possible allergy; slow infusion is recommended; not recommended in CRF</td>
</tr>
<tr>
<td>Diclofenac</td>
<td>75</td>
<td>PO</td>
<td></td>
</tr>
<tr>
<td>Tramadol</td>
<td>150</td>
<td>IM</td>
<td></td>
</tr>
<tr>
<td>Etodolac</td>
<td>50–75</td>
<td>Slow IV infusion</td>
<td>Nausea; start before end of surgery</td>
</tr>
<tr>
<td>Opioids</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buprenorphine</td>
<td>0.4</td>
<td>IV</td>
<td>Partial opioid receptor agonist. Rare psychomimetic effects; respiratory depression rare; PCA useful</td>
</tr>
<tr>
<td>Morphine</td>
<td>30–40</td>
<td>IV</td>
<td>Standard analgesic. IV bolus/infusion/PCA is optimal. Respiratory depression</td>
</tr>
</tbody>
</table>

CRF = chronic renal failure; IM = intramuscular; IV = intravenous; PCA = patient-controlled analgesia; PO = oral; PR = per rectum.

Effects. The aim of any analgesic technique should be to lower pain scores, facilitate earlier mobilization and reduce perioperative complications. The initial treatment could include opioids, such as intravenous morphine (up to 4 mg) or buprenorphine (0.4 mg), in divided doses, within the first postoperative 30–45 minutes, in order to achieve steady-state plasma concentrations and avoid drug accumulation while obtaining sufficient pain control (Weinbroum AA, unpublished data). Addition of NSAIDs, such as ketorolac 30–60 mg parenterally or intravenous lornoxicam 5–6 mg or tramadol 50–60 mg, is useful since this may reduce opioid consumption. With the exception of tramadol, such treatment also leads to a reduction in postoperative nausea and vomiting, and all improve ventilation. Use of meperidine should be discouraged because of the possibility of toxic metabolite normeperidine-associated adverse effects. Ketamine, given at a dose of 250–350 μg/kg intravenously concomitantly with morphine 0.7–1 mg by bolus, can be used as an adjuvant drug for postoperative analgesia in in-patients.

9. Discharge Criteria for the Elderly after MAC

Recovery is a continual process, the early stages of which overlap with the end of intra-operative care. Patients cannot be considered fully recovered until they have returned to their preoperative physiological state. Various scoring systems for evaluating patients’ physical condition in the immediate postoperative period have been created and thereafter simplified, and some are based on physiological parameters rating patients’ emergence from surgery and anaesthesia. Table IV sets out detailed discharge criteria proposed by Marshall and Chung. Korttila has also formulated guidelines for safe discharge after ambulatory surgery. According to this author, the patient should have stable vital signs for at least 1 hour and be fully oriented, able to dress, and able to walk unassisted. The patient should also have no postoperative nausea or vomiting, excessive pain or bleeding; have been discharged by both the anaesthetist and the surgeon (or their designates); have written instructions for home (including a contact phone, place and person); and have a responsible adult caring for him or her over the first 24 hours. Before discharge, pain must be minimal or non-existent, effectively controllable by oral analgesics and its location/type/intensity consistent with the anticipated discomfort.

10. Summary and Conclusion

The following key points summarize concerns regarding the elderly when undergoing procedures under MAC:
Table IV. Postanaesthesia Discharge Scoring System (PADS) for determining home readiness (reproduced from Marshall and Chung, with permission)

<table>
<thead>
<tr>
<th>1. Vital signs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Must be stable and consistent with age and preoperative baseline</td>
<td></td>
</tr>
<tr>
<td>BP/HR within 20% of preoperative baseline</td>
<td>2</td>
</tr>
<tr>
<td>BP/HR 20-40% of preoperative baseline</td>
<td>1</td>
</tr>
<tr>
<td>BP/HR &gt;40% of preoperative baseline</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. Activity level</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient must ambulate at preoperative level</td>
<td></td>
</tr>
<tr>
<td>steady gait, no dizziness, or meets preoperative level</td>
<td>2</td>
</tr>
<tr>
<td>requires assistance</td>
<td>1</td>
</tr>
<tr>
<td>unable to ambulate</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. Nausea and vomiting</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimal nausea and vomiting</td>
<td></td>
</tr>
<tr>
<td>minimal, successfully treated with oral medication</td>
<td>2</td>
</tr>
<tr>
<td>moderate, successfully treated with IM medication</td>
<td>1</td>
</tr>
<tr>
<td>severe, continues after repeated treatment</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4. Pain</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain acceptable to the patient</td>
<td></td>
</tr>
<tr>
<td>yes</td>
<td>2</td>
</tr>
<tr>
<td>no</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5. Surgical bleeding</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bleeding consistent with expected blood loss for the procedure</td>
<td></td>
</tr>
<tr>
<td>minimal, not requiring dressing change</td>
<td>2</td>
</tr>
<tr>
<td>moderate, requiring one to two dressing changes</td>
<td>1</td>
</tr>
<tr>
<td>severe, requiring more than three dressing changes</td>
<td>0</td>
</tr>
</tbody>
</table>

Discharge minimal total score ≥9

BP = blood pressure; HR = heart rate; IM = intramuscular.

- The physiology of aging is associated with a progressive loss of functional reserve in all organ systems.
- The extent and onset of these changes are highly variable from person to person, independently of chronological age.
- The elderly are more sensitive to anaesthetic agents than young patients, even if healthy. Thus, less medication is usually required to achieve the desired clinical effect, and drug effect is often prolonged.
- The greatest concern of the elderly patient is to maintain independence. Therefore, the most important outcome and the overall objective of the perioperative care of this population is to speed recovery, avoid functional decline and provide early home discharge.
- Surgical risk in patients aged ≥65 years depends primarily on the following factors: (i) age; (ii) physiological status, particularly mental; (iii) co-existing diseases (ASA class); (iv) type of procedure; and (v) whether the intervention is elective or urgent.
- When preoperatively evaluating a geriatric patient, there should be a high index of suspicion for disease processes commonly associated with aging.
- Prior to surgery, it is important to assess the degree of functional reserve of specific, pertinent organ systems as well as the patient as a whole.
- Routine testing based on age alone is currently not indicated. Instead, the patient should be selectively assessed on the basis of the history and physical examination and the specific surgical procedure.
- Evidence-based data suggest that preoperative co-morbid disease is a determinant of postoperative complications. Anaesthetic care should be tailored to co-morbid diseases and the requirements of the surgical procedure.
- Pre- and postoperative management of cardiac and pulmonary problems in the elderly is of particular importance in the prevention of morbidity and mortality.
- MAC is an anaesthetized condition; all monitoring required by the patient’s status and surgical procedure are to be maintained.
- Important postoperative issues when caring for the elderly include cognitive dysfunction and perioperative delirium.
- Pain is poorly accepted by the elderly; its optimal control speeds recovery and the patient’s independence and home discharge.

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