21 Geriatric Neuroanesthesia

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21.1 Introduction

The exact age for defining geriatric patient is still unknown, as aging is not a sudden phenomenon but is a continual process that is influenced by various factors such as coexisting diseases that can hasten process of aging. In recent era, the development of advanced technology, new equipment, and neuroanesthesia/neurointensive care has expanded and revolutionized the daily neurosurgical practice [1]. These techniques have enlarged the spectrum of conditions that are amenable to neurosurgical management. The proportion of geriatric population is following an increasing trend. Despite this, the literature regarding various interventions and their outcome in geriatric patients is limited [2–5].

The optimal management of geriatric patients is a challenge due to their depleted systemic reserves, polypharmacy, and geriatric syndromes. As compared to the younger patients, geriatric patients are at higher risk of adverse perioperative outcomes. Strong evidence is required to conclude whether neurosurgical intervention actually benefits these elderly patients or just increase the risk of perioperative morbidity and mortality. Previous study by Whitehouse et al. has reported that elderly patients should not be denied of neurosurgery just because of their age alone, as they have found improvement in general condition after neurosurgery [6]. A multidisciplinary team approach involving emergency medicine experts, geriatricians, surgeons, anesthetists, and intensivists should work together to improve outcome in these patients. For optimal management during perioperative period of these patients, we must be aware of the physiological changes associated with aging.

21.2 Physiological Changes of Aging

Under normal circumstances, aging takes place in all the organ systems spontaneously and gradually, beginning at conception [7]. The rate and course of aging vary widely from individual to individual and are influenced by their genetic makeup and environmental, socioeconomic, and psychological factors. There is a reduction in systemic reserve that reduces the normal physiological response during acute stressors, including anesthesia, surgery, and critical illness. Functional decline of various organ systems including cardiovascular (CVS), pulmonary, renal, central nervous (CNS), hematological/immunological, and musculoskeletal systems may influence perioperative outcomes. Table 21.1 summarizes various physiological changes with aging and their clinical relevance.

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Table 21.1 Physiological changes and their clinical significance

Organ system	Physiological change	Clinical significance
Cellular	Reduced lean body weight Intracellular fluid is reduced	Risk of dehydration
Neurological	Diminish cerebral volume Reduced cerebral perfusion Reduced neuronal conduction Reduction in all senses including vision, hearing, tactile, balancing Aging of hypothalamus makes these patients susceptible to hypothermia	Increased risk of confusion and delirium Increased sensitivity to hypoxia and hypotension Complicates the neurological examination Increased sensitivity to sedative and hypnotic agents Risk of delayed awakening Hearing aids and glasses should be kept on while examining the patient in awake craniotomy
Cardiovascular	Myocytes start to degenerate and replaced by connective tissues or fats Stiff ventricles Blood vessel wall also gets stiffened Autonomic system involvement leading to low fixed heart rate	Increased risk of conduction defects, arrhythmias, and heart block Lesser cardiac output High risk for pulmonary edema Increased risk of hypertension Compensatory response to blood/fluid loss is obtund High risk for hypotension in extremes of positions (sitting/prone)
Pulmonary	Reduction in lung and chest wall compliance Decreased number of functioning alveoli Weakness of respiratory muscles Poor mucociliary function	Early decompensation during hypoxia due to poor reserve Ventilation perfusion mismatch progressively increases with age High-risk postoperative pulmonary complications including pneumonitis and atelectasis
Renal system	Decreased renal blood flow and glomerular filtration rate Decreased concentration ability of urine and to conserve sodium	Vulnerable for ischemia during perioperative hypotension Increased sensitivity to potential nephrotoxic drugs like nonsteroidal anti-inflammatory drugs Risk of perioperative renal failure Altered pharmacokinetics and pharmacodynamics of the drugs Exaggerated response to diuretics leading to excessive dehydration
Musculoskeletal	Sarcopenia	Risk of residual muscle paralysis
	Osteopenia	Increased risk of fracture while positioning
	Stiff joint and tendons	Risk of spinal cord trauma in the presence of osteophytes
	Degenerative changes in spine and disc spaces	
	Decreased mobility	Increased risk of deep vein thrombosis
Integumentary	Epidermis atrophy	Delayed re-epithelisation of skin injuries
	Loss of subcutaneous adipose tissue	Diminished thermoregulation
	Easy separation of dermis and epidermis	Increases the risk for shear injuries pressure ulcers

21.2.1 Cellular Changes

The number of cells gradually reduces with aging, and these changes at cellular level influence all the physiological functions. Aging cells lack certain enzymes that may slow the effects of cell aging leading to age acceleration. There is a reduction in myocytes of skeletal muscles leading to loss of muscle mass [8]. These changes result in reduced lean body mass and increased total body fat [9]. In elderly patients, there is less total body fluid, cellular solids, and bone mass. Extracellular fluid is usually maintained, but intracellular fluid is reduced, rendering these patients at risk of early dehydration [10]. Administration of diuretics (mannitol) aggravates dehydration and might cause exaggerated hemodynamic instability intraoperatively.

21.2.2 Neurological Changes

With aging intelligence is not diminished, but cerebral volume and cerebral perfusion will decrease that may manifest as concentration difficulties, memory loss, and slowed reaction time [11–13]. The loss of neurons and slowing of nerve fiber conduction velocity decrease motor function, hearing, and vision. The dementia might mask acute neurological changes and further complicates the neurological examination [14]. Aging in the hypothalamus makes these patients susceptible to hypothermia. Performance of various sensory organs also gets weakened [10, 15]. Visual acuity is altered, visual field narrows, and pupillary reactions to light slow down as the pupil sphincter hardens (interferes with neurological examination). There is a progressive hearing loss due to the changes in inner ear. Degeneration of the vestibular apparatus results in loss of equilibrium and balance and tendency to fall. Tactile sensation is also reduced to sense pressure, pain, and temperature.

Age-related reduction in cerebral and cerebrovascular reserve results in a relatively high prevalence of postoperative delirium and cognitive dysfunction that delays discharge and functional recovery. Due to decreased CNS reserves, these patients are at risk of delayed awakening after anesthesia, and it must be distinguished from delayed awakening secondary to intracranial cause due to brain insult.

Hypertension is commonly encountered comorbidity in geriatric patients. Due to which cerebral autoregulation curve shifts toward right side, suggesting that lower limit of autoregulation is higher in these patients and the brain becomes ischemic at a higher mean arterial pressure.

21.2.3 Cardiovascular Changes

Cardiovascular diseases are the leading cause of death in this group of patients [16]. Aging alters both the anatomy and physiology of cardiovascular system [17]. The number of myocytes declines progressively, and myocardial collagen starts increasing [18]. Thus, myocardium becomes weak resulting in reduced contractile strength and cardiac output. The myocardium becomes stiff due to increased myocardial interstitial fibrosis [17, 19]. Slowly, myocytes are replaced by connective tissue and fat, that causes conduction defects, risk of sick sinus syndrome, atrial arrhythmias, atrioventricular blocks, and bundle branch blocks [19, 20]. Similarly, blood vessel walls also get stiffened and consequent in increased afterload and myocardial hypertrophy [17]. Both systolic and diastolic blood pressures rise with age to compensate for high peripheral resistance and low cardiac output. Due to lower cardiac output state, their myocardium is at risk of ischemia during increased metabolic demand situations [21].

The physiological changes in the autonomic nervous system result in decreased cardiovascular responsiveness to stress [22]. Elderly patients are effectively “beta-blocked” due to the decreased sensitivity of beta-receptors that limits the capability to increase cardiac output in response to fluid/blood losses. In the same manner, decreased sensitivity of baroreceptors and angiotensin-II responsiveness may further limit the response to hypovolemia. Consequently, it is crucial to maintain adequate circulating volume in geriatric patients.

Due to autonomic involvement, geriatric patients may develop severe hemodynamic instability during sitting or prone positions.

21.2.4 Pulmonary Changes

Aging affects both structure and function of respiratory system. There is a reduction in chest wall and lung compliance as age progresses. Various changes in ribs and costal cartilages (osteoporosis and calcification of the costal cartilage) make the trachea and rib cage more stiff and difficult to ventilate. Along with stiffness, there is a weakness of inspiratory and expiratory muscles that results in the use of accessory muscles even during normal breathing. These patients are high risk for developing pneumonia due to various age-related changes, including blunting of cough and laryngeal reflexes, decreased number of cilia, bronchial mucus gland hypertrophy, and decreased ability to expel pooled mucous and debris [23].

Pulmonary function is also affected due to reduced number, elasticity, and surface area of alveoli [17, 19]. These changes lead to decreased area available to gas exchange and lower the partial pressure of oxygen in arterial blood (PaO_2) [10]. In contrast, partial pressure of carbon dioxide in arterial blood ($PaCO_2$) remains unchanged with aging; therefore, hypercarbia is always considered pathological [17]. Due to these alterations, elderly patients are at risk of sudden decompensation in the presence of hypoxia and hypercapnia. Associated pulmonary diseases and smoking might complicate the situation further. With aging ventilation-perfusion mismatch increases.

21.2.5 Renal System

As age progresses there are structural and functional changes in the kidney that cause decreased renal blood flow and glomerular filtration rate (GFR) [24]. There is approximately 50% reduction in renal blood flow by the age of 80, because of decreased renal tubular mass and arteriole atrophy [19–21]. With aging there is a reduction in the capacity to concentrate urine and conserve sodium resulting in fluid and acid-base imbalances [25]. By the age of 85 years, GFR decreases by approximately 45% [19–21].

Various comorbidities such as hypertension and diabetes and the use of nephrotoxic drugs (particularly nonsteroidal anti-inflammatory drugs and ACE inhibitors) also lead to decline in renal function [26]. Renal function directly affects the pharmacokinetics and pharmacodynamics of anesthetic drugs and therefore should be assessed routinely in elderly patients before elective or emergency surgeries.

21.2.6 Gastrointestinal Changes

With aging, there is a decrease in the feeling of hunger and increase in the feeling of satiety [27, 28]. Other physiological changes are altered swallowing caused by oropharyngeal dysmotility, gastric and intestinal mucosal atrophy, reduced gastric acid and digestive enzyme secretion, and decreased esophageal and gastric motility [24, 28]. All these factors lead to the malabsorption of fats and vitamin B12 resulting in undernourishment, weakness, and debilitation.

The liver also reduces in weight, volume, and function with age that reduces the capacity to metabolize the medications [29]. Laboratory tests might show normal liver function tests. Impaired insulin secretion and increased peripheral insulin resistance render these patients high risk for glucose intolerance and type 2 diabetes [30].

21.2.7 Musculoskeletal Changes

Aging induced changes of musculoskeletal system, such as senile sarcopenia and loss of muscle mass which begins as early as the age of 30 years [20]. Various factors influence this degeneration including environmental, nutritional, hormonal, and immunological factors and physical activity. The myocytes are gradually replaced by fibrous connective tissue which results in reduced muscle mass, tone, and strength. With aging tendons, ligaments, and cartilage lose elasticity and joints become stiffer. Bone mass declines progressively with aging resulting in more susceptibility to fractures, tears, and dislocations [20]. The intervertebral discs also show degenerative changes, and these changes can cause neural compression during positioning under anesthesia [31]. Immobility contributes to a greater prevalence of thromboembolism and pressure necrosis [17].

21.2.8 Integumentary Changes

Various skin changes include epidermis atrophy, dermal collagen stiffening, loss of subcutaneous adipose tissue, and elastin calcification [32]. These changes lead to slow healing, reduced barrier protection, and delayed absorption of medications. Thinning of epidermis causes easy separation of dermis and epidermis and increases the risk for shear injuries and pressure ulcers. Age-related changes to the dermis such as decreased number of sweat glands, blood vessels, and nerve endings cause diminished thermoregulation. There is delayed reepithelization of skin injuries in elderly patients [20].

The neurosurgical procedures are done in diverse positions including supine, prone, sitting, and park-bench, and these procedures are usually of prolonged duration. If pressure points are not adequately padded, then chances of injuries to skin and peripheral nerves may increase.

21.3 Preoperative Assessment

"Perioperative risk" is defined as likelihood of adverse events related to surgery or anesthesia. Various factors contributing to the perioperative risk include modifiable or non-modifiable factors related to patient's comorbidities and deranged physiology and factors related to surgical procedure and anesthesia. Even though there are various risk stratification scores for perioperative morbidity, Portland modification score has been successfully used applied in neurosurgical patients [33]. Preoperative identification and optimization of modifiable risk factors decrease perioperative risk and improve surgical outcome.

21.3.1 Risk Related to the Surgical Procedure

Observational studies are conducted to estimate the surgical risk factors, but these vary from surgeon to surgeon and are influenced by institutional practices [34]. Adverse events are more common during emergency surgery as compared to elective surgeries [35]. Procedural risk may be decreased by using more meticulous surgical techniques, multidisciplinary perioperative approach, and better postoperative and rehabilitation care [36].

21.3.2 Risk Related to the Patient [37]

Aging is commonly associated with physiological decline, multiple comorbidities, and frailty, and these are independent risk factors for increased perioperative risk. Hence, preoperative assessment should involve a structured multifactorial approach in geriatric patients [38].

Table 21.2 enumerates the minimum criteria for preoperative geriatric patient's assessment based on recommendations given by the experts [33, 39–41].

21.4 Preoperative Optimization of the Older Surgical Patient

Preoperative assessment alone is insufficient without attempting the preoperative optimization. At the same time, we must balance the risks of delay in surgical procedure and benefits of optimization. It is suggested that optimization and surgery should take place simultaneously rather than consecutively in emergency setup [36]. Pre-optimization should be focused on reducing the risk of complications, mentioned in Table 21.3.

21.5 Decision-Making

Preoperative assessment allows us the determination of the risk to a patient of undergoing a particular intervention compared with the intended benefits [45].

21.6 Intraoperative Management

The general goals of neuroanesthesia are the same in elderly patient as in other group of patients, including maintaining appropriate intracranial pressure (ICP) and cerebral perfusion pressure (CPP); smooth induction and reversal techniques; avoidance of large hemodynamic fluctuations; and maintaining normocapnia and normoxia. Premedication must be given carefully and under monitoring as geriatric brain is more sensitive to the sedative/hypnotics and the response of these drugs aggravates in the presence of intracranial lesions. Invasive monitoring may be required to provide a beat-to-beat control of ICP and CPP. Intraoperative management of geriatric patients is described in Table 21.4.

Table 21.2 Preoperative assessment of geriatric patients

Domain	Items to be assessed	Appropriate assessment tools
Medical illness	Comorbidity/severity	
	• Cardiovascular	• Vital signs, ECG, echocardiography (if applicable), CPET
	• Respiratory	• Chest X-ray, SpO_2, pulmonary function tests, and arterial blood gases if required
	• Hematological	• Full blood count
	• Renal	• Urea and electrolytes, estimated glomerular filtration rate
	• Endocrinological	• Blood sugar
	• Nutritional	• Weight, body mass index, albumin (liver function tests)
	Previous anesthesia	Enquire about problems during previous exposure (difficult airway, cardiovascular liability, emergence delirium, delayed awakening)
	Presenting pathology	Radiological
Medication	Medication review	
	Anticoagulant therapy	Coagulation screen
	Relevant allergies	
Cognitive functions	Decision-making capacity	Abbreviated mental test score
	Communication	
	Preoperative depression	Vision, hearing, speech
	Alcohol dependence	
	Risk factors for postoperative delirium	
Functional capacity	Gait and balance	6-m walk
	Mobility	Walks unaided/with stick/with frame/does not walk Home-bound? (yes/no)
Use of functional aids	Visual Hearing Mobility Dentures	Glasses Hearing aids Walking stick, frame, wheelchair

ECG electrocardiogram, *CPET* cardiopulmonary exercise test

Table 21.3 Perioperative optimization

Postoperative complications	Measures to optimize
Organ-specific morbidity	Comorbidities should be optimized as per various guidelines for specific disease These guidelines might need to be tailored as per patient's needs, and risk of over-investigations and interactions of polypharmacy should be kept in mind
Ischemia	Age-related physiological is associated with organ-specific and generalized ischemia The brain and heart have high metabolic demands, and perioperative ischemia leads to dysfunction of these organs. So, interventions should be aimed at reducing oxygen demands and improving oxygen delivery These aims are achieved by maintaining adequate depth of anesthesia and analgesia, adequate thermoregulation, oxygenation, blood pressure, fluid balances, and hematocrit
Postoperative cognitive disorders (delirium and cognitive decline)	High-risk patients should be identified and optimized Intraoperative oxygenation and hemodynamics should be tightly controlled Early detection and management helps in reducing the prevalence, severity, and duration of POCD
Malnutrition	Adequate oral nutrition and supplementation of hematinics (if required) and vitamins should be started at least 28 days prior to elective surgery [42, 43] Prolonged fasting should be avoided preoperatively [44]
Functional decline	Currently there is inadequate evidence on postoperative rehabilitation of geriatric patients There should be a multimodal approach involving patient information and encouragement, recovery protocols, maintaining hemodynamic goals, employment of postoperative care bundles, and rehabilitation

Table 21.4 Intraoperative management of geriatric patients

Preoperative checklist	Sign in: before induction of anesthesia	Time out: before surgical incision
WHO Surgical Safety Checklist modified the checklist for geriatric patients	• Have vital signs been recorded (heart rate, blood pressure, heart rhythm, SpO_2, temperature)? • Is the patient's resuscitation status known? • Does the patient have dentures? • Does the patient have any preoperative pressure sores? • Has the site of any nerve block been confirmed and marked?	• Have possible areas of pressure damage been padded? • What is the patient's hemoglobin concentration? • What is the patient's eGFR?
Temperature control	Geriatric patients are more at risk of hypothermia Hypothermia is associated with increased risk of complications including [46, 47] • Postoperative delirium • Cardiac dysfunction • Prolonged hospital stay • Poor wound healing Measures should be taken to maintain temperature including [47] • Appropriate monitoring • Forced air warming/fluid warming	
Monitoring	Besides standard intraoperative monitors • Electrocardiography • Noninvasive blood pressure • Pulse oximeter • End-tidal carbon dioxide monitor Advanced and invasive monitors might be needed depending upon the presence of comorbidities and invasiveness of surgery (a) *Central venous pressure* • Due to poorly compliant ventricles and vasculature, central venous pressure does not correlate with actual blood volume [48] • Its use is more limited to the administering vasoactive drugs and parenteral nutrition (b) *Cardiac output monitor* • Esophageal Doppler (directed at aorta) directed guided cardiac output monitoring may be less accurate in the geriatric patients • Flow through stiff artery might overestimate cardiac output • Results in suboptimal fluid resuscitation [49, 50] (c) *Cerebral oxygen saturation* • Still under research and might decrease the prevalence of POD/POCD (d) *Bispectral index monitors (BIS) or entropy monitors* • Requirement of anesthetic agents reduces with age [51, 52] • If dosage of anesthetic agents is not tailored as per needs, it results in relative overdose and leads to prolonged recovery time and significant hypotension [53] • If these monitors are not available, then age-adjusted MAC values should be used [51] • "Triple low" (low BIS, low hypotension, and low inspired inhalational agent) is associated with higher mortality and prolonged inpatient stay [54] (e) *Peripheral nerve stimulation* Altered pharmacokinetics and pharmacodynamics of the drugs might lead to prolonged neuromuscular blockade, suggesting that neuromuscular function monitoring should be used routinely [55, 56]	
Fluid and electrolyte management	• Fluid and electrolyte therapy is challenging as there is weak cardiac compensation • There is no tachycardia of blood and fluid losses • Slight overhydration causes pulmonary edema • Prolonged preoperative fasting should be avoided	

(continued)

Table 21.4 (continued)

Preoperative checklist	Sign in: before induction of anesthesia	Time out: before surgical incision
Positioning	• Positioning should be made with care as there are associated skeletal deformities and osteoporosis • Elderly skin can be friable • Peripheral nerve injuries are common • All pressure sites should be well padded • Care should be taken during transfer of the patient on the operating table • Their skin is at risk of thermal damage. Warming devices should be carefully placed	
End-of-surgery checklist WHO Surgical Safety Checklist "sign out" [57]	Sign out: before patient leaves the operating theatre • What is the patient's core temperature? • What is the patient's hemoglobin concentration? • Have age-adjusted and renal function-adjusted doses of postoperative analgesia been prescribed? • Has a postoperative fluid plan been prescribed? • Can the patient be returned safely to a general care? • Ward?	
Perioperative analgesia	• Must be titrated carefully • Respiratory compromise may be a risk preoperatively • Inadequate analgesia may lead to postoperative delirium	
DVT prophylaxis	Must be started as soon as feasible	

DVT deep vein thrombosis, *POD* postoperative cognitive disorders, *POCD* postoperative cognitive decline

Additionally, functional aids (hearing aids, glasses, dentures) should remain in place until just prior to the induction of anesthesia. During awake craniotomy, we need to keep hearing and visual aid in place to examine patient's neurological status intraoperatively.

21.7 Specific Concerns for Common Neurosurgical Conditions (Table 21.5)

Various neurosurgical lesions commonly encountered in geriatric patients are listed in Table 21.5.

Table 21.5 Spectrum of lesions in geriatric patients

Intracranial lesions
Intracranial space-occupying lesions
• Intrinsic tumors
• Meningioma
• Metastatic malignant disease
• Cerebral abscess (less common)
Vascular
• Vascular disease, e.g., cerebellar infarction
• Stroke-ischemic/hemorrhagic
• Chronic subdural hematoma
• Arteriovenous malformation (less common)
Spinal cord and column
Degenerative diseases
• Lumbar canal stenosis
• Rheumatoid arthritis
• Prolapsed intervertebral disc (less common)
Metastatic tumors

21.7.1 Vascular Disease

In geriatric neurosurgery, vascular diseases are commonly divided into two main groups. One of them is where surgery is performed directly on the vessels such as aneurysm and carotid stenosis. Another category is where surgery is performed because of the consequences of vascular involvement, such as shunt placement in acute hydrocephalus following cerebellar infarction or decompressive hemi-craniotomy after complete middle cerebral artery territory infarct.

21.7.2 Carotid Artery Surgery

The degenerative diseases constitute a major burden of neurovascular diseases, particularly stroke, related to carotid stenosis [58]. A multicenter trial showed that in symptomatic patients with greater than 70% stenosis surgical interventions are superior over medical treatment. This leads to an increase in number of patients presenting for carotid endarterectomy (CEA) or carotid stenting. This group of patients usually has multiple comorbidities including hypertension, diabetes, ischemic heart disease, peripheral vascular disease, and smoking-related lung disease and might be on multiple pharmacological agents. Because of these comorbidities, anesthesia becomes challenging in these patients [59, 60]. The goals of anesthesia during these surgeries are maintenance of adequate cerebral perfusion pressure and avoidance of hypocapnia (leads to cerebral vasoconstriction and aggravates ischemia) and hypotension/hypertension (leads to myocardial ischemia and stroke, cerebral hyperperfusion, rupture of vascular suture line). Patients should be counselled regarding the perioperative risks of major complications such as myocardial infarction and stroke and the purpose of surgery. Myocardial infarction is the most common cause of perioperative death during these procedures. In patients over 75 years of age undergoing surgery, the risk of perioperative stroke rate is reported as 3.3% and total mortality as 2.1%. Surgery will not reverse the pre-existing deficit but will prevent future stroke and debilities that might occur due to major stroke [59]. In patients with severe degrees of stenosis, one should balance the risk firmly in favor of surgery.

21.7.3 Subarachnoid Hemorrhage (SAH)

In patients over 70 years of age, the incidence of SAH is about 3/100,000, and out of these, approximately 75% occur due to ruptured aneurysm. Other causes of hemorrhagic stroke such as arteriovenous malformation are more common in younger patients [61]. Perioperative management goals are the same as described in previous section. Hemodynamic management of vasospasm should be guarded as the risk of cardiopulmonary decompensation is high in the presence of stiff ventricles.

21.7.4 Chronic Subdural Hematoma

Chronic subdural hematoma (SDH) is common with increasing age. Due to loss of brain mass, the bridging veins between the dura and brain rupture easily leading to a chronic SDH. Patients with SDH usually present with dementia or gradual worsening of an existing mental status. The mechanism of the acute SDH is distinct from chronic SDH that usually occurs due to major head trauma, but in geriatric patients, acute SDH may follow a seemingly trivial trauma. Chronic SDH is managed by evacuation through burr holes under minimal sedation and local anesthesia or scalp block.

21.8 Intracranial Neoplasms

21.8.1 Malignant Tumors

Metastatic intracranial deposits depressingly form a larger proportion of neurosurgical cases in geriatric age group [62, 63]. The removal of metastasis deposits may result in extension of life to some extent and may improve quality of life. Excision of metastatic tumors is a usual neurosurgical procedure with a little blood loss and is managed in similarly as in younger patients.

21.8.2 Benign Tumors

The common benign tumors in geriatric age group are meningiomas and tumors of the eighth nerve. Slow-growing tumors might acquire a larger size before presentation in geriatric patients due to larger space available secondary to loss of brain volume. The strategy in surgical excision may be different in this age group [64]. One might go for attempted complete excision of a medium-sized acoustic neuroma in a young adult, while in the older patients, a debulking procedure with preservation of the facial nerve may be more sensible. These slow-growing tumors usually take time to recur, and patients may die due to some other associated pathology in natural course of disease before the recurrence. It might be technically easy to remove extra-axial tumors like meningiomas in the elderly patients, as atrophied brain allows a good exposure with lesser retraction and lesser need for decongestive measures such as mannitol and hyperventilation [65]. The slowly growing tumors may present with progressive intellectual deterioration in the elderly patients, and it may be confused with degenerative diseases like Alzheimer-type dementia. The intellectual capacity recovers satisfactorily following excision of such tumors. Preoperative embolization of vascular tumors can be considered to reduce blood loss and morbidity.

21.9 Spinal Diseases

The spectrum of spinal pathology is also different in young and elderly patients. Approximately 30% of neurosurgical interventions are related to spinal diseases in elderly patients, and out of which, 45% are related to degenerative spinal diseases such as cervical spondylotic myelopathy and lumbar canal stenosis [66]. Most common cause of spinal trauma is simple fall in the elderly, while road traffic accident is the leading cause in the young patients. Another category of disease predominantly seen in this group of patients is metastatic tumors. These lesions may be extremely vascular and might bleed torrentially intraoperatively. Neurofibroma and meningioma are commonly seen benign spinal tumors and are managed in a conventional way.

Intubation might be challenging in geriatric patients due to the presence of cervical osteophytes (causes cervical compression myelopathy) or rheumatoid arthritis (might be associated with atlanto-axial dislocation). Also, stiff and osteoporotic spine at this age might endanger spinal cord during intubation. Hence, care should be taken to prevent injuries to the spinal cord during intubation.

21.10 Trauma

As far as function is concerned, the elderly traumatic brain and spinal cord usually do not recover well following injury, and both the morbidity and mortality are much greater than the younger patients. In other neurosurgical diseases, patient's physiological state is more important than the chronological age in predicting the outcome. The mechanism of injury and outcome following evacuation of acute SDH are markedly different in young and old alike [67]. As in spinal trauma, the mechanism of injury is commonly a high-impact road traffic accident in younger population, whereas in elderly it may be a simple fall (approx. 55%) leading to the same severity of trauma.

After acute head injury, geriatric patients usually have poor outcome despite full resuscitation, including adequate ventilation, neuroprotection, maintaining an adequate cerebral perfusion pressure, and timely surgical intervention. In contrast, chronic SDH has a better outcome. A study comparing the mortality of patients over 65 years of age and under 40 years of age with GCS of <12 found that mortality was 75–100% in the former group while 18% in the latter group.

As with brain trauma, spinal injuries are also poorly tolerated by elderly patients as compared to younger patients. Spinal injuries are associated with mortality rates between 30% and 100% in patients with new onset tetraplegia in the over 65 years of age.

21.11 Trigeminal Neuralgia (TGN)

TGN is seen in middle-aged to elderly patients. TGN is successfully treated by three approaches including medical, surgical decompression of the trigeminal nerve in the posterior fossa, and percutaneous ablation of trigeminal nerve. Initially the patients are treated with pharmacological agents, but if pain is not controlled with pharmacological agents or side effects of drugs are intolerable, then surgical treatment is needed. The surgical technique involves posterior fossa exploration, exposure of the trigeminal nerve, and revealing of a microvascular compression (by a loop of superior cerebellar artery), and a graft is inserted between vessel and nerve. The complications of the procedure include all the hazards of posterior fossa surgery and most serious being the potentially fatal posterior fossa hematoma postoperatively.

The percutaneous approaches include ablation of trigeminal ganglion by injection of glycerol, balloon compression, or radio-frequency lesioning (RFL) by thermocoagulation. Insertion of the needle and lesion ablation are painful and may require general anesthesia or can be done in conscious patient. If general anesthesia is used, recovery should be rapid and complete after procedure to allow assessment of success of the treatment. Depending upon anatomy of patient and operator's experience, the needle placement may take a few seconds to minutes; hence a square-wave pattern of anesthesia is required. If sedation is planned, then one should be careful about apnea due to oversedation. During the procedure, as needle enters the ganglion, patient may develop hypertension, severe bradycardia, and even asystole. Close communication with patient is required during procedure, but the presence of hearing difficulty (deafness, dementia, residual anesthesia) might interfere with the assessment.

21.12 Interventional Neuroradiology

Intervention neuroradiology (INR) is being increasingly used for neurosurgical procedures. Being minimally invasive, INR is beneficial in the situations where either surgery is high risk such as basilar-top artery aneurysms or where patients are high risk due to associated comorbidities [68]. In carotid stenosis, the patients having severe cardiac disease and other associated systemic diseases that increase the perioperative risks are treated by carotid stenting in INR suite rather than carotid endarterectomy. INR involves lesser hemodynamic changes and better outcome.

Preoperative embolization of vascular tumors prior surgery may reduce intraoperative blood loss and decrease morbidity greatly. Anesthetic plan varies as per the procedure; preoperative embolization of tumors is usually done under local anesthesia and minimal sedation, whereas coiling of aneurysm is preferentially done under general anesthesia. INR becomes challenging when patient have associated cardiac and renal dysfunction. Flush fluids, intravenous fluids, and the use of contrast should be used in restricted dosage in patients with such comorbidities. Temperature should be monitored, and rewarming devices should be used as INR suites are usually kept at lower temperature to maintain proper functioning of machines, and elderly patients rapidly lose heat due to poor compensatory mechanisms.

21.13 Functional Stereotactic Neurosurgery

Therapeutic electrical stimulation of the CNS is being practiced in various diseases such as Parkinson disease, severe depression, chronic pain, and movement disorders. These procedures are usually performed under monitored anesthesia care and minimum sedation. Complications may arise during the procedure due to the preexisting comorbidities and drug interactions. Intraoperative complications include hypertension, airway obstruction, and seizures. Good preoperative preparation, proper patient selection and counselling, and increased vigilance intraoperatively will prevent or minimize these events [69].

21.14 Postoperative Management

Pre-existing systemic diseases, type of intracranial pathology, and local postoperative complications affect the postoperative course and outcome of geriatric patients. Advanced neuro-monitoring modalities including ICP and transcranial Doppler ultrasonography might help in early detection of intracranial complications [70]. Major postoperative complications are described wide infra.

21.14.1 Respiratory Complications

Due to diminished physiological reserve, geriatric patients are at increased risk of postoperative pulmonary complications. In addition to these changes, in patients with posterior fossa lesions and upper cervical spine, there is decreased cough and pharyngeal reflex that may increase the risk of postoperative aspiration. Adequate analgesia incentive spirometry, chest physiotherapy, and toileting or protection of airway (endotracheal tube/tracheostomy) might prevent aspiration.

21.14.2 Postoperative Delirium and Cognitive Decline

Causes of postoperative delirium are multifactorial including urinary tract infection, hypoxia, hypercarbia, hyperthermia, fluid shifts, and electrolyte imbalance.

21.14.3 Rehabilitation

A multidisciplinary team involving medicine experts, geriatricians, surgeons, anesthetists and intensivists helps to bring these patients to the premorbid functional states.

21.15 Conclusion

As we are growing grayer, our expectations are also growing, and neurosurgical interventions are also being increasingly done in the elderly patients. There are various studies that show surgeries in elderly patients are successful most of the times and can avoid long-term disability and dependence, and age alone should not be the criteria to decide in favor or against the surgery. It is the presence and severity of coexisting pathology that also affects the outcome in these patients rather than age alone. In traumatic and emergency surgeries, age directly affects the outcome, and geriatric patients with severe trauma usually carry a poor prognosis. In patients with compromised physiological reserve, where surgery is associated with higher intraoperative morbidity and mortality, INR plays a major role. With adequate preoperative optimization, skillful perioperative management, and clinical common sense, a good outcome can be achieved in elderly neurosurgical patient.

Key Points

- The perioperative management of geriatric patients is challenging due to their depleted systemic reserves, polypharmacy, and geriatric syndromes.
- A multidisciplinary team approach involving emergency medicine experts, geriatricians, surgeons, anesthetists, and intensivists should work together to improve outcome in these patients.
- Preoperative identification and optimization of modifiable risk factors decrease perioperative risk and improve surgical outcome.
- Premedication must be given carefully and under monitoring as geriatric brain is more sensitive to the sedative/hypnotics and the response to these drugs is intensified in the presence of intracranial pathology.
- Functional aids (hearing aids, glasses, dentures) should remain in place until just prior to the induction of anesthesia and intraoperatively during awake craniotomy.

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