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Cognitive Disorders and Psychological Problems Linked to Surgery: Anesthesia-Related Cognitive Issues and Prevention Strategies

Hassan Noor[1,2], Adrian Coțe[3*], Alexandra Micu[2], Valentin Pirvut[1,2]

[1]Department of Medicine, Faculty of Medicine, "Lucian Blaga" University, Sibiu, Romania.
[2]Hospital Medlife-Polisano, Sibiu, Romania.
[3]Department of Surgical Discipline, Faculty of Medicine and Pharmacy, University of Oradea, 410087 Oradea, Romania.

***E-mail** ✉ Adrian.cote@gmail.com

Abstract

Cognitive disorders are among the important complications that can occur in association with surgery and anesthesia and require proactive planning and precautionary measures before surgical intervention. Overlooking or being unaware of the contributing factors can significantly increase the risk of developing such issues. This review article aims to examine the underlying causes and contributing factors associated with cognitive problems that occur in the perioperative period. This article seeks to reduce the onset and progression of these complications after surgery by highlighting effective preventive measures. To conduct this analysis, a wide range of relevant literature published between 1990 and 2022 was reviewed. References were accessed through prominent academic databases such as PubMed, Google Scholar, and ScienceDirect. The review included search terms such as cognitive problems, psychological problems, and complications related to anesthesia and surgery to collect comprehensive data. The study emphasizes a variety of crucial considerations that should be addressed to reduce the likelihood of developing cognitive problems in surgical and anesthetic settings. These include the administration of neuroprotective agents, the appropriate use of psychoactive medications, evaluation of the anticholinergic system, and monitoring of the depth of anesthesia. Special attention was paid to pediatric populations, where vulnerability is often increased. Additional factors discussed encompass circadian rhythm disruptions and sleep disturbances, respect for patient privacy, regulation of blood glucose levels, accommodation of patients' spiritual or religious practices, maintenance of hemoglobin and electrolyte balance, stabilization of blood pressure, as well as monitoring via capnography and oxygen saturation. The positioning of the patient during procedures, potential embolic events, pharmacological interactions, cardiac performance, platelet function, psychological stress, pain management, temperature regulation, prolonged hospitalization, development of ileus, and the appropriate use of antibiotics were also examined as integral components of prevention strategies.

Keywords: Anesthesia, Cognitive disorders, Cognitive problems, Surgery, Psychological problems

Introduction

With advancements in science, anesthesiology has increasingly intersected with the fields of neuroscience and psychology. Emerging studies now indicate that the administration of anesthesia and the process of surgery may trigger neuropsychological and behavioral disturbances in patients, like how traumatic brain injuries impair cognitive functioning. Within this scope, substantial progress has been made in identifying risk factors and preventive strategies aimed at reducing the occurrence of cognitive issues post-surgery [1].

Surgical procedures expose patients to a broad spectrum of possible complications, not only in vital systems such as the lungs, heart, and kidneys but also in terms of neuropsychological health. For this reason, optimal outcomes require that clinical personnel maintain both clinical vigilance and emotional sensitivity at the patient's bedside, with the dual aim of safeguarding the

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patient from intraoperative harm and ensuring prompt resolution or mitigation of postoperative challenges [2].

Institutions that neglect to properly assess and address neuropsychological vulnerabilities in patients are more likely to see a rise in postoperative cognitive problems. These complications can emerge within 24 hours of surgery and may linger for extended durations, occasionally persisting for life [2, 3]. Postoperative cognitive disorders primarily fall into two categories: postoperative delirium and postoperative cognitive dysfunction. Postoperative delirium is defined by a rapid onset of cognitive disruption, involving deficits in attention and focus, an inability to respond to instructions, impaired speech, and either subdued or exaggerated physical movement, usually occurring immediately or within a day after the operation [2, 4].

The occurrence of delirium spans a wide range—from 3% to as high as 50%—and is largely dependent on the patient's pre-existing risk profile. This condition is associated with prolonged hospitalization, a higher likelihood of mortality, and potential long-term deterioration in cognitive function [3]. On the other hand, postoperative cognitive dysfunction tends to develop gradually, from several days to even months after surgery, presenting with symptoms such as compromised memory, impaired concentration, and attention, difficulties in communication, changes in personality, mood disturbances like depression or aggression, and decreased motivation or physical activity [2].

Scholars have identified a broad array of risk elements that must be carefully evaluated before surgical procedures commence. The cumulative presence of these risk factors significantly heightens the likelihood of developing postoperative cognitive disorders. By addressing and mitigating these factors proactively, the incidence of POCD may be considerably diminished. The risk profile includes critically ill patients, individuals of advanced age (particularly over 70), baseline cognitive decline, limited educational background, pre-existing dementia or Alzheimer's disease, a medical history of psychiatric or neurological illness, hypoalbuminemia, dehydration, general frailty, metabolic imbalances, tobacco or psychoactive substance use, motor dysfunctions, electrolyte irregularities, systemic infections or inflammation, and those who have undergone extensive surgeries such as cardiac, orthopedic, or thoracic procedures [3, 5].

This review aims to analyze the underlying causes and contributing factors responsible for cognitive disturbances in the perioperative period. By highlighting these elements, the article intends to offer practical solutions that may help curb the emergence and spread of cognitive disorders following surgery.

Materials and Methods

To compile this review, the authors conducted an extensive exploration of scholarly publications spanning from 1990 to 2022, concentrating on literature that examined the origins of cognitive problems and outlined approaches for their prevention. Databases such as PubMed, Google Scholar, and ScienceDirect served as the primary platforms for sourcing these materials. Specific search terms, including cognitive problems, psychological problems during anesthesia, after anesthesia, and surgery, were utilized to filter relevant content. Following a thorough evaluation of article abstracts, only those studies deemed directly aligned with the subject matter were selected, and the essential information was extracted to inform the analysis presented in this review.

Results and Discussion

This review focused on identifying and evaluating strategies that can be employed during anesthesia and surgical procedures to prevent the onset of cognitive problems.

Neuroprotective interventions

Several agents with neuroprotective properties have been explored for their potential to reduce the incidence of postoperative cognitive dysfunction (POCD). Magnesium, known for its neuroprotective capabilities, may play a valuable role in this context. Lidocaine, when administered as an intraoperative infusion at a dosage of 1 mg/kg, has shown some benefit in lessening the severity of POCD. Glucocorticoids, particularly dexamethasone, have been found to mitigate both inflammation and POCD-related complications following surgery. Intravenous progesterone has been identified for its neuroprotective, anticonvulsant, and analgesic effects, particularly within neurosurgical and obstetric settings. Melatonin, a hormone essential to circadian rhythm regulation, also exhibits neuroprotective qualities; its therapeutic administration—especially in patients dealing with sleep disorders, depression, MS, or delirium—may prove

useful if given the night before and after surgical intervention. In addition, certain medicinal herbs, although typically advised against during the week before surgery, may contribute positively to neurological stability and reduce anesthesia-related side effects when used postoperatively [1, 6–11].

Anesthetic drugs

The choice of anesthetic agents can significantly influence postoperative cognitive outcomes. Studies indicate that total intravenous anesthesia (TIVA) using propofol is associated with a reduced risk of delirium post-surgery, especially when compared to isoflurane in both pediatric and elderly groups. However, midazolam—particularly in high doses or continuous infusions—has been implicated in memory deficits postoperatively, with elderly patients being particularly vulnerable. Benzodiazepine-induced delirium is also a concern in older adults due to their naturally reduced central cholinergic activity, compounded by the anticholinergic properties of these drugs. In such cases, haloperidol may offer a more appropriate alternative to midazolam for managing postoperative delirium. If midazolam is employed during regional anesthesia, careful titration between 0.2 to 0.3 mg/kg is advised, with close observation of the patient's response. Extra caution is warranted in individuals with respiratory conditions, psychiatric illness, or severe sleep disturbances, as midazolam can exacerbate issues such as hypoventilation, excessive sedation, and sleep disruption post-surgery. Patients with hepatic conditions such as fatty liver or hyperlipidemia may also experience prolonged drug action and heightened sensitivity to both midazolam and nesdonal.

Cesarean-section patients may face an increased likelihood of developing postpartum depression (PPD), particularly those with prior prenatal depression, emotional trauma during pregnancy, or socio-familial stressors. For high-risk individuals, the use of magnesium sulfate (4 mg/kg) during anesthesia induction, combined with intraoperative infusion, and the administration of ketamine at doses between 0.5 to 0.8 mg/kg, has been shown to significantly reduce the chances of developing PPD. Additional strategies—such as post-surgical herbal therapy using agents like chicory, ginger, or saffron, along with enhanced familial support and spiritual care—can further promote emotional stability and recovery [4, 6, 11–14].

Anticholinergic system

The brain's cholinergic system, supported by acetylcholine at neuronal synapses, plays a vital role in sustaining cognitive integrity. Disruption of this system—whether through disease or pharmacological interference—has been linked to cognitive impairment. Certain anesthetic drugs carry anticholinergic effects that can heighten the risk of delirium and cognitive issues, particularly among children and the elderly. Abrupt changes in cholinergic neurotransmission, especially over prolonged periods, can induce adverse neuropsychological consequences. Patients with pre-existing neurological or psychological disorders are more vulnerable to these alterations, increasing their susceptibility to cognitive disturbances post-surgery. Conditions such as hyperactive delirium and anticholinergic syndrome are frequently cited outcomes of such disruptions. To counteract these effects, medications like rivastigmine and donepezil are occasionally administered in cases of postoperative delirium, particularly in elderly patients or those diagnosed with Alzheimer's disease [1, 15–18].

Depth of anesthesia

Inadequate anesthetic depth—specifically, when anesthesia remains too shallow—can lead to undesirable neurological outcomes such as intraoperative awareness, the formation of unconscious memories, or the occurrence of REM activity during surgery. These disturbances may eventually result in psychological repercussions like PTSD, phobic responses, depressive episodes, or vivid recall of the procedure. Conversely, overly deep anesthesia can elevate the risk of developing postoperative delirium. Thus, maintaining precise anesthetic titration is essential. In obese individuals, propofol administration through pump infusion must be calculated based on the patient's total body weight, assuming the liver function is uncompromised and no hypersensitivity to the drug exists. Administering anesthesia based solely on lean body mass in such patients may result in inadequate dosing. Ensuring patient safety requires a holistic approach—this includes the clinical competence and empathy of healthcare personnel, familiarity with anesthetic pharmacology, understanding of each patient's medical history, accurate assessment of anesthetic depth, and proper management of analgesia and muscle relaxation. Additionally, surgical complexity and duration, the effective use of anesthesia equipment, and synchronized teamwork up to the final

phase of the operation are critical components to minimizing recall events [15, 16, 19, 20].

Pediatrics and emerging problems

Children demonstrate heightened vulnerability to neuropsychological disturbances post-surgery, often manifesting as maladaptive behaviors. Reports indicate that around 23% of pediatric patients may display such reactions for up to two weeks postoperatively, with some persisting for months. Symptoms may include aggression, sleep disruptions, excessive worry, anxiety, disobedience, nightmares, and heightened emotional sensitivity. Various risk factors have been associated with these outcomes, such as being under the age of three, heightened anxiety in the child or parents, perioperative stress, unmanaged pain, prolonged hospitalization, delayed discharge, and undergoing genitourinary procedures. Other contributors include anesthetic technique or dosage errors and the presence of respiratory or cardiac complications throughout the perioperative period. To help mitigate the development of POCD and maladaptive responses, healthcare providers are encouraged to counsel families at discharge. Recommended strategies include engaging children in cognitive and physical activities, promoting familial harmony, utilizing behavioral guidance and education, supporting spiritual practices, and emphasizing a neuro-supportive diet and the use of medicinal herbs that enhance memory and emotional balance [11, 21–23].

Sleep and circadian disorders

Disturbances in sleep following surgery often stem from disruptions in REM or NREM cycles, or conditions like insomnia, nighttime awakenings, delayed sleep onset, or recurrent nightmares. REM sleep—typically marked by paralysis of body muscles aside from the eyes and heightened brain activity—is the phase associated with dreaming, while NREM sleep features more muscular activity but reduced brain arousal. Postoperative sleep issues can arise from numerous causes, including persistent pain, nausea, use of narcotics and anesthetics, preexisting sleep and mental health conditions, circadian misalignment, sleep apnea, or stress-induced factors. Additional contributors include electrolyte imbalances, anticholinergic reactions, thermal instability, or underlying chronic diseases such as diabetes mellitus. Preoperative detection of insomnia warrants a more carefully tailored anesthetic plan, with attention to sedative and analgesic dosing to avoid exacerbation. Histamine-related allergies may provoke nighttime arousals, whereas antihistamines can enhance sleep. Postoperative fatigue, immobility, and lack of mental stimulation may intensify mood disturbances and interfere with circadian regulation. Patients with pre-existing histories of pain, fatigue, or nausea who do not receive appropriate management often experience worsening symptoms following surgery [1, 7, 11, 24–27].

Preservation of patient privacy

Upholding the confidentiality and personal boundaries of patients is a principle enshrined in the global Patient Bill of Rights. Breaches of privacy—including disregard for religious beliefs or personal dignity—can negatively affect patient well-being, leading to emotional distress, dissatisfaction with care, anxiety, depression, sleep disturbances, and the development of phobias. Recognizing and respecting each patient's spiritual and personal identity is essential in providing ethical and compassionate medical care [1, 28–30].

The patient's spiritual manners

A patient's sense of spiritual connection, especially through practices such as prayer and devotion, can significantly enhance emotional resilience and promote swifter recovery—both physically and psychologically. Spiritual support has gained increasing recognition in modern therapeutic approaches and is now regarded as an effective complementary strategy. When spiritual needs are acknowledged and addressed, patients often exhibit improved coping mechanisms, reduced mental distress, and greater overall satisfaction with their care. Thus, fostering a healing environment that embraces patients' spiritual values may contribute to improved clinical outcomes and a more meaningful recovery experience, while also aligning with broader ethical and spiritual goals [6, 31].

Blood sugar

Maintaining blood glucose levels within the 100 to 180 range during surgical procedures is vital, as glucose plays a fundamental role in energizing brain cells. Disruptions in this balance—particularly in vulnerable individuals—can lead to adverse effects. Hypoglycemia suppresses neuronal function, significantly delaying emergence from anesthesia. Conversely, hyperglycemia can promote POCD by triggering metabolic imbalances and inflammatory responses, a concern that becomes especially critical in patients with preexisting cerebral damage. When individuals experience intense physical or

psychological stress preoperatively or intraoperatively, the secretion of hormones such as cortisol, catecholamines, growth hormone, and thyroid hormones causes hyperglycemia by elevating glucose levels, reducing insulin secretion, and lowering insulin sensitivity. Hence, it is essential to monitor the patient's stress response, anesthetic depth, and medication use to minimize complications from elevated blood sugar, particularly in high-risk patients [11, 32].

Electrolytes

There is compelling evidence linking disturbances in electrolyte levels to neurocognitive disorders such as dementia, depression, and Alzheimer's disease. In particular, hyponatremia has been tied to altered neurological function, increased postoperative morbidity and mortality, and a heightened incidence of POCD. Patients undergoing neurosurgery or those with cranial tumors or injuries may experience syndromes like inappropriate ADH secretion or natriuretic peptide release, both of which contribute to sodium imbalance. Additionally, neuropsychological conditions and certain medications exacerbate susceptibility to hyponatremia. Vulnerable populations—including children, neuropsychiatric patients, and women—are particularly prone to sodium disturbances. Rapid correction of either hyponatremia or hypernatremia can inflict neural damage. Other imbalances, such as hypokalemia, hypomagnesemia, and hypophosphatemia, are also implicated in the development of POCD. When acid-base status is disrupted alongside hypokalemia or hyperkalemia, the likelihood of cellular injury rises due to impaired perfusion [1, 11, 32].

Hemoglobin

Risk factors contributing to POCD include anemia, acute or chronic blood loss, dehydration, and deficiencies in vitamin B12. These conditions undermine oxygen delivery and neuronal integrity during and after surgery [11, 33].

Blood pressure

Fluctuations exceeding 30% from baseline mean arterial pressure during anesthesia are associated with heightened postoperative morbidity and mortality. The consequences of both hypotension and hypertension depend on their intensity, duration, and etiology during the operation. Complications may include acute renal injury, myocardial damage, and ischemic harm to sensitive tissues, including the brain. Particular risk groups—such as the elderly, individuals with cardiovascular conditions, anemia, significant blood loss, or chronic pulmonary diseases—are more likely to sustain damage from hemodynamic instability. Hypotension is often linked to spinal or epidural blocks. While tissue perfusion is generally autoregulated, this mechanism can be impaired under certain pathological states, resulting in inadequate blood flow and cellular injury. Conditions that can disturb cerebral autoregulation and compromise the blood-brain barrier include diabetes mellitus, chronic hypertension, obstructive sleep apnea, excessive smoking, elevated CO_2 levels, head trauma, brain neoplasms, multiple sclerosis, extended high-fat feeding, schizophrenia, and severe depressive disorders. Factors like patient positioning, vasodilator/vasoconstrictor agents, and specific anesthetics (excluding sevoflurane) may further aggravate these issues [29, 34, 35].

Oxygenation and capnography

Hypoxia remains a major contributor to neuronal and tissue damage, especially in sensitive individuals. While pulse oximetry readings between 95 and 100 often correspond to PaO_2 levels from 60 to 160 mmHg, values below 95 warrant further investigation. A pulse oximeter reading of 75 may reflect a PaO_2 of approximately 40 mmHg, indicating dangerously low arterial oxygenation. For patients with cardiopulmonary comorbidities, precise evaluation of PaO_2 and SpO_2 via ABG analysis is advisable. Hypercapnia causes cerebral vasodilation and elevates ICP, while prolonged or severe hypocapnia can contribute to POCD. In some instances, conditions such as acidosis and impaired cerebral perfusion increase the risk of embolic events. Thus, meticulous respiratory monitoring and maintenance of normocapnia are essential throughout surgery [11, 33].

Posture and position of patient

Patient positioning during surgery influences hemodynamic and neurological outcomes. For instance, elevating the head can generate a negative pressure gradient between the surgical veins and the right heart, potentially allowing air embolism. This position also reduces cerebral perfusion pressure (CPP) and impairs brain circulation. Prone positioning, on the other hand, can similarly diminish CPP due to decreased neck vessel flow, lowered cardiac output leading to hypotension, and elevated ICP or CVP. These factors increase POCD risk. Vision loss may occur from compromised ocular

perfusion in this posture. Individuals with preexisting vulnerabilities are more likely to suffer from position-induced complications. As such, any condition—particularly hypotension—that arises in conjunction with risky surgical positions magnifies the danger and severity of neurologic injury [1, 36–38].

Drug interactions

Overlooking potential interactions between drugs can lead to serious perioperative complications. For instance, statin therapy, commonly used for managing blood lipid levels, carries a rare risk of inducing rhabdomyolysis and myopathy—effects that may be amplified when combined with succinylcholine, indirectly heightening the chance of developing POCD. Another notable interaction involves the simultaneous or immediate administration of thiopental sodium alongside neuromuscular blockers such as atracurium, curonium, rocuronium, or succinylcholine. This combination can cause precipitate formation, especially during rapid sequence induction. Such precipitates may delay the onset of drug action, raising the risk that the patient remains conscious during intubation or experiences regurgitation. To mitigate this, it is recommended that after administering Nasedonal, the IV line or infusion set be flushed thoroughly before introducing the muscle relaxant [11, 39].

Emboli

Surgical procedures may precipitate embolic events, which can severely impair various organs, including the brain. Intraoperative contributors include surgical positioning, hemolytic reactions, compromised tissue perfusion, drastic hemodynamic shifts, fat embolism during orthopedic operations, amniotic fluid embolism in obstetric procedures, and coagulation abnormalities [11, 33, 40, 41]. Embolism manifestations may include oxygen desaturation, lower $ETCO_2$, increased respiratory rate, audible wheezing, lung crackles, and declining cognitive performance. For patients already burdened by underlying conditions such as cardiovascular, neurological, renal, pulmonary, hepatic disorders, or cancer, the onset of embolism can significantly worsen prognosis and elevate both morbidity and mortality rates [42, 43].

Platelet activity

Elevated platelet reactivity is another contributor to cognitive disturbances. This hyperactivity is associated with increased gene expression and surface presence of molecules like GPIIb-IIIa and P-selectin, promoting platelet aggregation and adhesion at vascular injury sites. Additional biochemical factors including CAMP, PAF, COX, thromboxane, prostaglandins, and serotonin release further exacerbate inflammatory processes and thrombus formation. These mechanisms can compromise cerebral perfusion, particularly in individuals with carotid artery pathology, thereby increasing the risk of POCD. While anticoagulant therapy is commonly prescribed to prevent embolic events, some research highlights the adjunctive use of herbal remedies. However, potential interactions between herbal and conventional medications necessitate professional consultation, especially regarding dosage and safety [11, 44].

Cardiac function

Patients with cardiovascular disease, especially those undergoing extensive surgical procedures, face a greater likelihood of experiencing POCD. Conditions such as chamber enlargement, atrial fibrillation, congestive heart failure, valvular anomalies like mitral or aortic stenosis and prolapse, as well as right-to-left cardiac shunting, have all been identified as contributing factors that increase the susceptibility to cognitive complications postoperatively [1, 11, 45].

Hypothermia and hyperthermia

Although certain studies suggest that hypothermia may offer neuroprotection against POCD, others have reported no conclusive benefit. Prolonged or intense hypothermia may depress cardiac output and tissue perfusion, posing risks, especially to frail or vulnerable patients. Conversely, rapid rewarming may elevate systemic inflammatory mediators, thereby increasing the incidence of POCD. Hyperthermia, whose effects remain incompletely understood, may also trigger adverse outcomes. One known condition associated with elevated body temperature is serotonin syndrome, which manifests as agitation, excessive movement, rapid heartbeat, pupil dilation, convulsions, gastrointestinal upset, and muscle breakdown. This syndrome is more likely when multiple serotonergic agents—such as fluoxetine, sertraline, methylene blue, meperidine, fentanyl, lithium, and nortriptyline—are concurrently used. Therapeutic measures can include the administration of midazolam and cyproheptadine. Additionally, metabolic deficiencies like hypothyroidism may further aggravate POCD risk [11, 46].

Pain and stress

Pain and psychological stress are key contributors to the progression of POCD, primarily due to their influence on hormonal pathways. Elevated pain and stress levels lead to increased secretion of cortisol and catecholamines, which can disrupt neural activity within central brain regions. Research has demonstrated a correlation between heightened stress responses and postoperative memory impairment. As such, administering corticosteroids must be done cautiously, taking into account both the dosage and the rate of administration as well as appropriate clinical justification. Individuals with conditions such as Cushing's syndrome, schizophrenia, chronic anxiety, persistent fears, or phobic disorders are at a heightened risk of experiencing memory dysfunction after surgical interventions. Interestingly, when administered in proper doses and via infusion, dexamethasone has shown potential in lowering the incidence of POCD. Conversely, high doses or inappropriate indications for its use may worsen POCD symptoms and trigger a range of psychiatric effects including mania, depression, anxiety, panic attacks, altered behavior, and neuropsychomotor disturbances. These adverse outcomes are thought to stem from alterations in dopaminergic and cholinergic transmission, reduced serotonin activity, and neurotoxic damage to the hippocampus. Additionally, unrelieved bladder distension during anesthesia can lead to unfavorable hemodynamic shifts and a rise in inflammatory mediators, thereby amplifying the likelihood of POCD. Not emptying the bladder before anesthesia or sleep has been linked to extended REM phases, neuroinflammatory reactions, and increased psychological stress [47, 48].

Delayed discharge

Postoperative delays in hospital discharge have been associated with reduced patient morale, a slower recovery trajectory, and a higher occurrence of postoperative complications [49].

Ileus and antibiotics

The gut-brain axis plays a significant role in modulating cognitive function through intricate pathophysiological mechanisms involving the digestive system. The human gastrointestinal tract harbors extensive microbial populations that constitute its natural flora, which can directly or indirectly influence brain activity. Disruptions in this microbial environment—triggered by dietary changes, psychological stress, or the long-term or inappropriate use of antibiotics and probiotics—may lead to dysbiosis and subsequent cognitive disturbances. Infections arising from unchecked microbial overgrowth and inadequate antibiotic intervention can affect the gastrointestinal system and exert detrimental effects on other organ systems. Postoperative ileus, a condition marked by impaired bowel motility, contributes to POCD by promoting gut dysfunction, prolonging hospital stays, and causing systemic hemodynamic instability. Inadequate blood flow to visceral organs can result in gut tissue injury and systemic inflammatory responses, which may extend the recovery period and exacerbate damage to other tissues [1, 11, 50].

Conclusion

Cognitive dysfunction stands out as a critical complication associated with surgical procedures and anesthesia, highlighting the necessity for preoperative strategies aimed at minimizing such risks. The emergence of these disorders is often linked to a lack of proper understanding and insufficient attention to the contributing factors. This review aimed to explore the multifaceted causes of perioperative cognitive issues, emphasizing the importance of identifying and addressing these elements to reduce their incidence in postoperative settings. The analysis presented in this study focused on key preventive measures and considerations that should be integrated into anesthesia and surgical protocols to mitigate cognitive decline. Among the pivotal aspects discussed were the application of neuroprotective agents, management of psychoactive and anticholinergic medications, regulation of anesthesia depth, pediatric susceptibility, disruption of circadian rhythms and sleep, preservation of patient privacy, glycemic control, attention to individual spiritual practices, and monitoring of hemoglobin, electrolyte balance, blood pressure, capnographic data, and oxygen levels. Other essential elements included ensuring proper patient positioning, managing embolic risks, recognizing and avoiding harmful drug interactions, evaluating cardiac performance, monitoring platelet reactivity, addressing stress and pain responses, controlling temperature extremes such as hypothermia and hyperthermia, minimizing discharge delays, and managing gastrointestinal factors like ileus and antibiotic-related effects.

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