

Assessment of Patient-Specific Risk Factors as Correlates of Nerve Susceptibility during Administration of Anesthesia to Patients

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Abstract: Nerve susceptibility during the administration of anesthesia remains a significant concern in perioperative practice due to its potential to cause transient or permanent neurological complications. Increasing evidence indicates that anesthesia-related nerve injury is strongly influenced by patient-specific risk factors rather than anesthetic technique alone. This study focuses on the assessment of individual patient characteristics—including demographic variables, medical comorbidities, metabolic and neurological conditions, anatomical variations, and lifestyle-related factors—as correlates of nerve susceptibility during anesthesia administration. By examining how these intrinsic factors interact with perioperative anesthetic practices, the study emphasizes the importance of comprehensive preoperative evaluation and risk stratification in minimizing nerve injury. The study concluded that failure to identify and account for these intrinsic vulnerabilities may increase the likelihood of anesthesia-related nerve complications, even when standard safety protocols are followed. It also recommended that routine comprehensive preoperative neurological assessment should be incorporated into standard anesthetic evaluation to identify pre-existing neuropathies, metabolic disorders, or functional limitations that may increase nerve susceptibility.

Key points: Anesthesia, Nerve Susceptibility, Patient-Specific Risk Factors, Perioperative Care.

INTRODUCTION

The administration of anesthesia is a fundamental component of modern surgical and diagnostic procedures, enabling pain control, immobility, and physiological stability. Despite its indispensable role, anesthesia is not without risks, one of the most concerning being anesthesia-associated nerve susceptibility and injury. Nerve injuries occurring in the perioperative period, though relatively infrequent, may result in significant functional impairment, prolonged hospitalization, chronic pain, and reduced quality of life. These complications also carry substantial medico-legal and economic implications for healthcare systems. Increasing evidence suggests that nerve susceptibility during anesthesia is not solely dependent on technical or procedural factors but is strongly influenced by patient-specific risk factors. As a result, contemporary anesthesia practice places growing emphasis on individualized patient assessment to identify those at increased risk. Understanding how intrinsic patient characteristics correlate with nerve vulnerability is therefore essential for improving perioperative safety and optimizing anesthetic outcomes (Welch et al., 2021; Neal et al., 2022).

Patient-specific risk factors encompass a broad range of demographic, physiological, and pathological characteristics that may predispose individuals to nerve susceptibility during anesthesia. Age is a well-recognized determinant, with elderly patients exhibiting reduced neural resilience due to age-related microvascular changes and diminished regenerative capacity. Similarly,

extremes of body mass index, including obesity and severe underweight, have been associated with increased risk of nerve compression and ischemia during anesthesia. Comorbid conditions such as diabetes mellitus, hypertension, peripheral vascular disease, and chronic kidney disease further compromise neural perfusion and axonal integrity, heightening vulnerability to anesthetic-related insults. These factors often coexist, creating a cumulative risk profile that may significantly amplify the likelihood of nerve injury. Recognizing the multifactorial nature of patient-specific risks underscores the need for systematic assessment rather than reliance on isolated risk indicators (Stafford et al., 2020; Brull et al., 2021).

Metabolic and neurological conditions play a particularly critical role in determining nerve susceptibility during anesthesia. Diabetes mellitus, for instance, is strongly associated with microvascular dysfunction and pre-existing peripheral neuropathy, both of which reduce the nerve's tolerance to mechanical compression, ischemia, and local anesthetic exposure. Similarly, patients with documented neuropathies, spinal disorders, or previous nerve injuries exhibit altered neural architecture that may be more susceptible to further damage. Nutritional deficiencies, especially of B-complex vitamins, impair myelin synthesis and nerve conduction, further increasing vulnerability. The presence of these conditions necessitates heightened vigilance during anesthetic planning and execution. Recent studies emphasize that failure to identify and account for such patient-specific neurological and metabolic factors significantly increases the risk of perioperative nerve complications (Neal et al., 2022; Welch et al., 2021).

Beyond medical comorbidities, lifestyle-related and functional factors also contribute meaningfully to nerve susceptibility during anesthesia. Chronic alcohol consumption, smoking, and prolonged sedentary behavior have all been linked to impaired neural and vascular function. Alcohol-related neurotoxicity and smoking-induced vasoconstriction reduce oxygen delivery to neural tissues, rendering them more susceptible to ischemic injury under anesthetic conditions. Additionally, reduced mobility or musculoskeletal deformities may necessitate non-standard positioning during surgery, increasing the risk of nerve stretch or compression. These factors are often underemphasized in routine preoperative evaluations despite their clear relevance to nerve health. Incorporating a more holistic assessment that includes lifestyle and functional status allows for a more accurate estimation of nerve injury risk and supports tailored anesthetic strategies (Stafford et al., 2020; Brull et al., 2021).

The relevance of patient-specific risk assessment becomes even more pronounced in the context of regional and neuraxial anesthesia, where direct interaction with neural structures occurs. While techniques such as ultrasound guidance have significantly improved safety, patient-related factors remain critical determinants of outcome. Anatomical variations, pre-existing spinal pathology, and altered tissue planes may increase the technical difficulty of nerve blocks and raise the likelihood of unintended nerve trauma or local anesthetic neurotoxicity. Moreover, patients with compromised neural reserve may experience exaggerated responses to otherwise standard anesthetic doses. Current literature increasingly supports the integration of patient-specific risk profiles into decision-making regarding anesthetic technique selection, dosage, and monitoring intensity, reinforcing the role of individualized care in preventing nerve susceptibility (Hadzic et al., 2020; Neal et al., 2022).

Concept of Nerves

Nerves are vital biological structures that serve as communication channels between the central nervous system and the rest of the body. They are responsible for transmitting electrical impulses and chemical signals that enable sensation, movement, reflex actions, and internal regulation. In modern physiology, nerves are viewed as highly organized bundles of neuronal fibers that allow rapid and coordinated responses to internal and external stimuli. According to Kandel et al. (2021), nerves form the functional link through which the brain interprets information and directs appropriate responses.



Fig.1: A Picture of Nerves in human body

Axons from neurons make up the structural components of nerves, which are shielded by layers of connective tissue called the endometrium, epineurium, and epineurium. Schwann cells form a myelin sheath that insulates many axons, greatly increasing the speed and efficiency of impulse conduction. Recent neurobiological studies emphasize that damage to any of these structural components can impair signal transmission and overall nerve performance (Jessen & Mirsky, 2021).

Based on the direction and kind of impulses they carry, nerves are functionally divided into sensory (afferent), motor (efferent), and mixed nerves. To perceive sensations like pain, temperature, and touch, sensory nerves carry information from receptors to the central nervous system. To enable movement and secretion, motor neurons transmit signals from the central nervous system to muscles and glands. Mixed nerves combine both functions, ensuring efficient two-way communication within the body (Bear, Connors, & Paradiso, 2020).

Through the autonomic nervous system, nerves are also essential for involuntary body regulation. Without conscious effort, autonomic nerves regulate vital physiological functions like blood pressure, respiration, digestion, and heart rate. Research indicates that the balance between sympathetic and parasympathetic nerve activity is crucial for maintaining homeostasis and adapting to stress (McCorry, 2022). This highlights the importance of nerves beyond voluntary actions, extending to life-sustaining processes.

Clinically, optimal health and functioning depend on the integrity of nerves. Conditions including neuropathy, paralysis, and sensory loss can result from damage or degeneration of nerves, greatly impairing quality of life. Recent developments in neuroscience highlight neuron regeneration and repair as potential therapeutic targets for neurological conditions. As noted by Zochodne (2023), understanding the structure and function of nerves is fundamental for improving therapeutic strategies in neurology and rehabilitation medicine.

Concept of Anesthesia

According to Miller, Eriksson, Fleisher, Wiener-Kronish, and Cohen (2020), anesthesia is a medically induced and reversible state in which pharmacological substances acting on the central and peripheral nerve systems reduce feeling, including pain. Depending on the anesthetic method used, this condition may involve variable degrees of forgetfulness, analgesia, muscle relaxation, and unconsciousness. In order to execute surgical and diagnostic procedures safely and humanely, anesthesia is intended to suppress the body's physiological and psychological reactions to surgical trauma while maintaining vital life processes including breathing, circulation, and thermoregulation.

Furthermore, Sanders, Tognoni, Laureys, and Sleigh (2018), describe anesthesia as a controlled alteration of brain activity that disrupts conscious awareness and sensory perception. According to this view, anesthetic drugs interfere with neuronal communication by acting on neurotransmitter systems and neural networks responsible for consciousness, memory, and responsiveness. This disruption prevents the integration of sensory information in the brain, ensuring that painful or distressing stimuli are not consciously experienced during medical procedures. According to Nagelhout and Elisha (2018), which defined anesthesia as a patient-centered clinical intervention that enables individuals to undergo invasive medical and surgical procedures without pain, fear, or psychological distress. Beyond the elimination of pain, anesthesia plays a critical role in maintaining physiological stability by controlling vital parameters such as heart rate, blood

pressure, oxygen saturation, and ventilation. This individualized approach to anesthesia care improves surgical outcomes and supports smoother postoperative recovery.

According to Butterworth, Mackey, and Wasnick (2022), anesthesiology is a multidisciplinary medical science and clinical practice that focuses on using controlled anesthetic treatments to prevent pain, awareness, and suffering during medical procedures. Preoperative patient evaluation, intraoperative monitoring, and postoperative pain management are all included in this concept, which goes beyond intraoperative care. Pharmacology, physiology, technology, and patient-centered care are all integrated into modern anesthesia to provide the best possible safety, comfort, and clinical results throughout the perioperative phase.

Concept of Nerve Susceptibility

The concept of nerve susceptibility refers to the inherent vulnerability of peripheral nerves to injury when exposed to mechanical, ischemic, metabolic, or chemical stressors. Peripheral nerves, composed of axons, Schwann cells, and connective tissue sheaths, rely on an adequate blood supply, intact myelin, and structural integrity to maintain normal function. When any of these components are compromised, the threshold for nerve injury decreases, making otherwise minor insults clinically significant. Nerve susceptibility is not uniform across individuals; rather, it is influenced by patient-specific factors such as age, comorbidities, metabolic status, and anatomical variations (Bais et al., 2024; Callaghan et al., 2020).

Nerve vulnerability is mechanistically caused by a confluence of vascular, metabolic, and structural variables. Structurally, nerves with prior injury or anatomical variations may have altered fiber orientation or reduced connective tissue support, which increases vulnerability to compression or traction forces (Schwabl et al., 2023). Metabolically, conditions such as diabetes mellitus leads to axonal degeneration, demyelination, and impaired Schwann cell function, which reduce the regenerative capacity of nerves and make them more sensitive to local anesthetics or ischemia (Levy et al., 2021; Kim et al., 2024). Vascularly, reduced perfusion due to peripheral vascular disease or microangiopathy compromises oxygen and nutrient delivery to the nerve, lowering its tolerance to mechanical and ischemic insults (Giron et al., 2021).

Recent research emphasizes that nerve susceptibility is dynamic and context-dependent. Acute factors, such as inflammation, systemic infection, or exposure to neurotoxic medications, may transiently increase vulnerability, while chronic factors, including age-related degeneration and comorbidities, create a baseline predisposition to injury (Staff et al., 2020; Paśnicki et al., 2024). In clinical practice, it is essential to comprehend nerve susceptibility, especially in anesthesia, surgery, and critical care, where procedures, positioning, or injections may unintentionally cause nerve damage. Recognition of susceptible patients allows clinicians to tailor anesthetic techniques, optimize positioning, employ ultrasound guidance for nerve blocks, and implement preventive strategies that reduce the risk of peripheral nerve injury (Bais et al., 2024; Malik et al., 2020).

Concept of Administration of Anesthesia

The administration of anesthesia is a systematic and scientifically grounded process aimed at achieving reversible loss of sensation, consciousness, and reflexes while maintaining physiological stability throughout surgical and diagnostic procedures. It encompasses a continuum of care that begins before the procedure, continues intraoperatively, and extends into the postoperative recovery period. Modern anesthesia practice is patient-centered and evidence-based, integrating pharmacological principles, physiological monitoring, and clinical expertise to ensure safety and optimal outcomes (Miller et al., 2020).

The preanesthetic examination, which enables the anesthetist to evaluate the patient's medical history, comorbid conditions, airway state, and procedural risks in order to create a customized anesthetic strategy, is fundamental to the idea of administering anesthesia. Contemporary studies emphasize that thorough preoperative assessment significantly reduces anesthesia-related complications by guiding appropriate drug selection, dosing, and monitoring strategies (Apfelbaum

et al., 2020). Prior to the onset of anesthesia, this phase also entails patient education, informed consent, and physiological parameter adjustment.

In order to establish hypnosis, analgesia, and amnesia, the induction phase entails starting anesthesia using intravenous or inhalational drugs. Propofol, opioids, and neuromuscular blocking drugs are among the medications that are given in precisely determined dosages depending on the patient. Recent literature highlights the importance of precise drug titration during induction to avoid hemodynamic instability and respiratory compromise, particularly in high-risk patients (Sahinovic et al., 2021). Anesthetic medication delivery is now more predictable and safe because of developments in pharmacokinetics and pharmacodynamics.

Anesthesia is maintained at a suitable depth throughout the maintenance phase to guarantee unconsciousness and immobilization while maintaining essential organ function. This stage requires constant monitoring of neurological, respiratory, and cardiovascular markers. Modern anesthesia administration increasingly relies on advanced monitoring tools, including processed electroencephalography, to guide anesthetic depth and reduce the risk of intraoperative awareness and postoperative cognitive dysfunction (Punjasawadwong et al., 2020). The idea of dynamic adjustment during maintenance emphasizes that anesthesia is not a static drug delivery method but rather an active, responsive process.

The safe cessation of anesthetic drugs and the restoration of consciousness, airway reflexes, and spontaneous breathing are the main goals of the emergence and recovery period. The goal of effective administration during this stage is to reduce problems like delirium, nausea, vomiting, and postoperative pain. Current research supports the use of multimodal analgesia and enhanced recovery protocols, in which anesthetic management plays a critical role in accelerating postoperative recovery and improving patient satisfaction (Kehlet & Joshi, 2021).

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Types of Patient-Specific Risk Factors to Nerve Susceptibility

Diabetes mellitus, obesity, peripheral vascular disease, and anatomical variations

By changing neuronal metabolism, vascular supply, mechanical tolerance, and structural integrity, patient-specific factors have a substantial impact on peripheral nerves' vulnerability to injury. Contemporary literature consistently identifies diabetes mellitus, obesity, peripheral vascular disease, and anatomical differences as key causes of increased nerve sensitivity.

➤ Diabetes mellitus

One of the well-documented disorders linked to increased nerve sensitivity is diabetes mellitus. Chronic hyper glycaemia induces metabolic and structural changes within peripheral nerves, including oxidative stress, accumulation of advanced glycation end products, impaired axonal transport, Schwann cell dysfunction, and progressive demyelination (Callaghan et al., 2020). In addition, diabetes causes microangiopathy of the vasa nervorum, leading to reduced endometrial blood flow and diminished oxygen delivery (Levy et al., 2021). These changes reduce the ability of nerves to tolerate ischemia and compression and significantly impair regenerative capacity following injury. Even in the absence of overt diabetic neuropathy, subclinical nerve dysfunction is common, which explains the increased incidence and severity of nerve injury observed in diabetic patients during surgery, regional anesthesia, and prolonged immobilization (Kim., 2024).

➤ **Obesity**



Fig.2: A Picture of Obesity

Nerve vulnerability is increased by obesity through metabolic and mechanical factors. Excess adipose tissue puts pressure on nerves that go via small anatomical tunnels and on superficial nerves, making them more vulnerable to compression neuropathies. In perioperative and critical care settings, obesity complicates positioning and increases the duration and magnitude of focal pressure on vulnerable nerve sites, which has been linked to a higher incidence of pressure-related nerve injuries (Malik et al., 2020). Beyond mechanical effects, obesity is associated with chronic low-grade inflammation, insulin resistance, and dyslipidemia, all of which impair micro vascular function and contribute to small-fiber neuropathy (Azmi et al., 2021). Evidence that nerve fiber density and function may improve following significant weight loss further supports the role of obesity-related metabolic stress in nerve vulnerability (Azmi et al., 2021).

➤ **Peripheral vascular disease**

By reducing blood flow, peripheral vascular disease significantly reduces nerve resiliency. Peripheral nerves depend on an intact micro vascular network for metabolic homeostasis, and atherosclerotic disease reduces perfusion of the vasa nervorum, leading to chronic nerve ischemia (Giron et al., 2021). Reduced endoneurial blood flow lowers the threshold at which compression, edema, or hypotension produces ischemic nerve injury. Furthermore, chronic hypoperfusion limits the inflammatory and reparative processes required for nerve regeneration, resulting in delayed or incomplete recovery following injury (Giron et al., 2021). Patients with peripheral vascular disease therefore face an elevated risk of nerve damage in surgical and perioperative contexts.

➤ **Anatomical variations**

Anatomical changes are a patient-specific risk factor for nerve vulnerability that is non-pathological yet clinically significant. The risk of mechanical injury or compression can be greatly increased by differences in nerve origin, course, branching pattern, and depth in relation to skin and bony landmarks. Studies of upper and lower limb anatomy have demonstrated that many peripheral nerves deviate from classical descriptions, placing them at unexpected risk during surgical dissection, needle placement, or positioning (Schwabli et al., 2023). In regional anesthesia, unrecognized anatomical variants may lead to direct needle trauma or intraneural injection despite adherence to standard techniques (Paśnicki et al., 2024). Similar to this, abnormal or superficial nerve courses make a person more susceptible to traction and external compression injuries.

Mitigating Strategies of Anesthesia Caused Nerve Susceptibility

In contemporaneous procedural dermatology, anesthesia-induced nerve vulnerability is a significant yet regularly overlooked problem that affects patient safety, clinical results, and medico-legal accountability. Anesthesia-related nerve damage can affect both the peripheral and central nervous systems, resulting in anything from temporary sensory abnormalities to long-term motor deficits and chronic neuropathic pain. Due to the vast number of surgical procedures carried out worldwide, large-scale studies show that even though the reported incidence is relatively low, the total number of affected individuals remains clinically significant. Numerous factors, such as ischemia, inflammatory reactions, mechanical compression, and the direct neurotoxicity of anesthetics, can lead to nerve sensitivity. General anaesthesia abolishes protective reflexes and muscle tone, making nerves more vulnerable to prolonged pressure or malpositioning, while regional anaesthesia may expose nerves to needle trauma or local anaesthetic toxicity. Importantly, patient-related factors

such as diabetes mellitus, hypertension, obesity, malnutrition, advanced age, and pre-existing neuropathies further increase susceptibility to nerve injury. These factors underscore the need for comprehensive, evidence-based strategies aimed at prevention rather than treatment. Contemporary literature increasingly emphasizes that most anaesthesia-related nerve injuries are preventable through meticulous planning, technical precision, and multidisciplinary collaboration, making mitigation strategies a central component of quality anaesthetic care (Welch et al., 2021; Stafford et al., 2020).

The pathophysiology of anaesthesia-related nerve susceptibility is complex and involves both direct and indirect mechanisms that compromise neural integrity. One of the primary contributors is mechanical injury, which may result from excessive stretching, compression, or prolonged immobilization of nerves during surgery. Loss of consciousness and neuromuscular blockade eliminate the patient's ability to reposition in response to discomfort, allowing sustained pressure on vulnerable nerve pathways. Ischemic mechanisms also play a critical role, as hypotension, hypoxia, anemia, and tourniquet application can reduce neural perfusion, leading to ischemia-reperfusion injury. At the cellular level, ischemia disrupts axonal transport, mitochondrial function, and ion channel regulation, predisposing nerves to injury. Additionally, local anaesthetic agents have been shown to exert dose-dependent neurotoxic effects, particularly when injected intraneurally or administered in high concentrations for prolonged durations. Experimental and clinical studies have demonstrated that local anaesthetics can induce Schwann cell apoptosis, axonal degeneration, and inflammatory responses, further heightening nerve vulnerability. When these mechanisms interact with patient-specific risk factors, the likelihood of nerve injury increases substantially, highlighting the importance of early risk recognition and targeted mitigation strategies (Brull et al., 2021; Neal et al., 2022).

Preoperative mitigation strategies form the foundation of nerve injury prevention and begin with a thorough patient evaluation and risk stratification process. A detailed medical history should focus on identifying conditions known to predispose patients to neuropathy, including diabetes mellitus, chronic kidney disease, vitamin deficiencies, alcohol use, and previous nerve injuries. Baseline neurological examination and documentation are essential, as they allow clinicians to distinguish pre-existing deficits from new postoperative complications. Preoperative planning should also consider the type and duration of surgery, anticipated patient positioning, and the need for regional or neuraxial anaesthesia. In high-risk patients, alternative anaesthetic techniques or modified approaches may be warranted to reduce nerve exposure. Informed consent plays a critical ethical and legal role, requiring transparent discussion of potential nerve-related complications, particularly for regional blocks and prolonged procedures. Recent studies emphasize that individualized anaesthetic planning, guided by patient risk profiles and procedural demands, significantly reduces the incidence of nerve injury. By integrating preoperative assessment with shared decision-making, anaesthetists can proactively minimize nerve susceptibility and enhance patient trust and safety (Stafford et al., 2020; Neal et al., 2022).

Intraoperative mitigation strategies are among the most effective interventions for reducing anaesthesia-induced nerve susceptibility, as they directly address the mechanical and ischemic factors responsible for neural injury. Proper patient positioning is paramount and requires careful attention to joint alignment, limb support, and pressure point padding. Avoidance of extreme flexion, extension, or rotation of limbs helps prevent nerve stretch injuries, while periodic reassessment during long procedures reduces the risk of prolonged compression. The adoption of ultrasound-guided regional anaesthesia has revolutionized nerve protection by allowing real-time visualization of neural structures, needle placement, and local anaesthetic spread. Evidence suggests that ultrasound guidance significantly reduces the risk of intraneural injection and improves block accuracy. Combining ultrasound with nerve stimulation provides an additional safety layer by confirming functional proximity without direct nerve contact. Furthermore, limiting injection pressure and using the lowest effective concentration of local anaesthetic reduce the likelihood of neurotoxicity. These intraoperative practices, when consistently applied, have been shown to

markedly decrease the incidence of anaesthesia-related nerve injuries (Hadzic et al., 2020; Brull et al., 2021).

Physiological optimization during surgery is another critical component of mitigating nerve susceptibility, as neural tissue is highly sensitive to perfusion and oxygenation disturbances. Maintaining stable hemodynamics ensures adequate blood flow to peripheral and central nerves, reducing the risk of ischemic injury. Episodes of sustained hypotension, hypoxia, or hypothermia should be promptly corrected, as they can exacerbate neural vulnerability, particularly in patients with compromised microcirculation. The use of surgical tourniquets requires careful consideration, as excessive inflation pressure and prolonged duration have been strongly associated with postoperative neuropraxia and axonal injury. Current evidence supports the use of the lowest effective tourniquet pressure and limiting inflation time whenever possible. In lengthy procedures, intermittent deflation may help restore neural perfusion and reduce ischemic damage. Effective communication between anaesthetists and surgeons is essential to balance surgical field requirements with nerve protection strategies. Together, vigilant physiological monitoring and collaborative decision-making significantly contribute to minimizing anaesthesia-induced nerve injury (Welch et al., 2021; Neal et al., 2022).

Postoperative strategies focus on early detection, timely intervention, and long-term recovery from nerve injury, thereby completing the continuum of nerve protection. Early postoperative neurological assessment is essential for identifying deficits as soon as anaesthetic effects resolve. Prompt recognition allows clinicians to differentiate transient sensory changes from true nerve injury, facilitating early referral for neurological evaluation and diagnostic studies when necessary. Effective pain and inflammation control using multimodal analgesia reduces secondary nerve injury caused by edema and inflammatory processes. Patients with confirmed or suspected nerve injury benefit from early physiotherapy and rehabilitation, which improve functional outcomes and reduce the risk of chronic neuropathic pain. From a systems perspective, continuous education of anaesthesia providers, adherence to updated clinical guidelines, and routine auditing of nerve injury cases are vital for sustained improvement. Recent literature emphasizes that a proactive, system-based approach combining education, protocol standardization, and early intervention significantly reduces the burden of anaesthesia-related nerve injury. Collectively, these postoperative and organizational strategies reinforce patient safety and enhance the overall quality of perioperative care (Stafford et al., 2020; Welch et al., 2021).

Proper Methods of Anesthesia Administration to Patients

➤ General Anesthesia

During major surgical procedures, general anesthesia is used to induce total unconsciousness, analgesia, and muscle relaxation. It is administered via inhalation, intravenously, or a mix of the two. Thorough preoperative evaluation, cautious anesthetic medication titration according to patient age and comorbidities, safe airway management, and ongoing vital sign monitoring during the procedure are all necessary for proper administration. Recent studies emphasize individualized dosing and depth-of-anesthesia monitoring to reduce postoperative complications such as respiratory depression and postoperative cognitive dysfunction (Brown et al., 2020; Sanders et al., 2022).

➤ Regional Anesthesia

By injecting local anesthetic around peripheral nerves or nerve plexuses, regional anesthesia blocks nerve conduction to a particular area of the body. This technique reduces systemic drug exposure and maintains awareness while delivering effective analgesia. In order to prevent nerve damage, proper administration necessitates progressive injection, the use of ultrasound guidance, excellent anatomical understanding, and avoidance of excessive injection pressure. Literature from recent years shows that ultrasound-guided regional anesthesia improves accuracy and reduces complications compared with landmark-based techniques (Neal et al., 2021; Paśnicki et al., 2024).

➤ **Spinal Anesthesia**

Local anesthetic is injected into the subarachnoid space to produce spinal anesthesia, which results in a quick and complete blocking of sensation and movement. Lower limb, pelvic, and lower abdominal procedures frequently employ it. Strict aseptic procedures, precise anatomical landmark identification, suitable medication dosage, and careful observation for hypotension and high spinal block are all components of proper technique. Current guidelines stress careful patient selection and evaluation of anticoagulation status to minimize neurological complications (Kopp et al., 2021).

➤ **Epidural Anesthesia**

A catheter is inserted into the spinal space during epidural anesthesia to enable the continuous or sporadic delivery of anesthetic drugs. It is frequently used for major thoracic or abdominal procedures as well as labor analgesia. Correct catheter installation, a test dose to prevent intrathecal or intravascular injection, and ongoing monitoring of sensory level and hemodynamic condition are all components of proper delivery. Recent evidence supports epidural anesthesia as an effective method for pain control while reducing systemic opioid requirements (Bajaj et al., 2020).

➤ **Local Anesthesia**

Administering anesthetic drugs directly into tissues to inhibit sensation in a small area is known as local anesthesia. For small surgical procedures, it is frequently utilized. In order to prevent intravascular administration, proper administration necessitates slow injection with aspiration, accurate determination of maximum safe dosages, and monitoring for symptoms of systemic toxicity from local anesthetics. Updated reviews emphasize early recognition and prompt management of toxicity to improve patient safety (El-Boghdadly et al., 2021).

➤ **Monitored Anesthesia Care (MAC)**

Intravenous sedation and local anesthesia are used in monitored anesthesia care while maintaining spontaneous ventilation. It is appropriate for diagnostic interventions and minimally invasive operations. As noted by Tawakalit & Arisekola, (2024) Technologies such as, AI, blockchain, IoT devices enable real time monitoring, predictive analysis and increased operational performance. Carefully titrating sedatives, continuously monitoring breathing and oxygenation, and being prepared to switch to general anesthesia if necessary are all part of proper administration. Recent guidelines recommend routine use of capnography during MAC to enhance patient safety (Apfelbaum et al., 2020).

In conclusion, the assessment of patient-specific risk factors as correlates of nerve susceptibility during the administration of anesthesia is a critical component of safe and effective perioperative care. Failure to identify and account for these intrinsic vulnerabilities may increase the likelihood of anesthesia-related nerve complications, even when standard safety protocols are followed. A comprehensive, individualized risk assessment enables anesthesiologists to make informed decisions regarding anesthetic technique selection, drug dosing, patient positioning, and intraoperative monitoring, thereby reducing preventable nerve injuries. Emphasizing patient-specific evaluation aligns with the principles of personalized medicine and promotes a proactive, preventive approach rather than reactive management of complications. Ultimately, integrating structured risk assessment into routine anesthetic practice has the potential to enhance patient safety, improve clinical outcomes, and contribute to the development of evidence-based guidelines aimed at minimizing nerve susceptibility during anesthesia administration.

RECOMMENDATIONS

- Routine comprehensive preoperative neurological assessment should be incorporated into standard anesthetic evaluation to identify pre-existing neuropathies, metabolic disorders, or functional limitations that may increase nerve susceptibility.
- Continuous education and training of anesthesia personnel on patient-specific risk factors and nerve injury prevention strategies should be strengthened through workshops, clinical

guidelines, and quality improvement programs to promote safer anesthetic practice.

- Close intraoperative physiological monitoring should be maintained to prevent hypotension, hypoxia, hypothermia, and prolonged ischemia, all of which significantly increase nerve vulnerability during anesthesia.

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