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Neurologic Complications Associated With Spinal Anesthesia

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Abstract

Spinal anesthesia is a widely used regional anesthetic technique that offers numerous advantages in perioperative care is essential for surgical patient, yet it carries inherent hazards, including potential neurological complications following spinal anesthesia have garnered significant attention in recent years. This abstract provides a concise overview of the key aspects explored in the article.

Neurological complications encompass a spectrum of adverse events, ranging from transient symptoms to more severe and enduring conditions. This article delves into the multifaceted factors associated with such complications, emphasizing the importance of anesthetic agent choice, patient-specific risk assessment, and procedural techniques in determining their occurrence. Additionally, it examines the relative risks of various local anesthetic agents and their potential to mitigate these complications.

As our understanding of these complications evolves, this article highlights the need for a proactive and multidisciplinary approach to patient care. Comprehensive preoperative evaluations, meticulous intraoperative management, and vigilant postoperative monitoring are discussed as essential components in minimizing the incidence and severity of neurological complications. Furthermore, it underscores the importance of ongoing research to refine clinical practices and optimize patient outcomes.

In conclusion, the article serves as a valuable resource for healthcare providers and anesthesiologists, offering insights into the complexities of neurological complications following spinal anesthesia. By embracing proactive strategies and staying abreast of the latest research findings, clinicians can further enhance patient safety and the overall quality of care in this specialized field.

Introduction

Interthecal anesthesia is a type of regional anesthesia that requires the administration of specific anesthetic medications into a fluid containing cavity housing the spinal cord and the nerves originating from it, are suspended using a fine long the medication subsequently blends with the cerebrospinal fluid, influencing the nerve fibers by inhibiting their function temporarily. This results in the lower part of the body, below the point of injection, becoming insensate and anesthetized, while the remainder of the body maintains its regular activity. This fluid-filled area is referred to as the subarachnoid space, and the administration of the injection takes place in the vicinity of the lumbar (lower back) spine.This form of anesthesia is easy to administer and is ideally suited for surgeries performed in the lower parts of the body(1).

The central nervous system (CNS) includes not only the brain and spinal cord but also the cerebral-spinal system. The term neuraxial anesthesia pertains to the administration of local anesthetic within or in proximity to the CNS. Spinal anesthesia is a neuraxial anesthesia method involving the direct introduction of a local anesthetic into the intrathecal space (subarachnoid space). The subarachnoid space contains sterile cerebrospinal fluid (CSF), the clear liquid that envelops the brain and spinal cord. In an average adult, there is approximately 130 to 140 mL of CSF, which undergoes continuous circulation throughout the day. Around 500 mL of CSF is generated daily(2).

Incidence of neurologic complication in central neuraxial blockade (CNB) is reported to be between 1/1000 and 1/1,000,000 higher with spinal than for epidural anaesthesia. Various causes of neurologic complications have been documented in the literature, as chemical myelitis, injury to the cord, or prexisting neurological lesion, but incidence of paraplegia following regional anaesthesia in situations involving congenital deformities, occurrences of such nature are exceedingly infrequent. We present an exceptional case of congenital lumbar agenesis, an exceptionally uncommon condition, which resulted in complete paraplegia accompanied by bowel and bladder complications subsequent to a spinal anesthesia administered during an urgent cesarean section. The primary objective of our case report is to raise awareness among anesthesiologists, surgeons, and neurologists regarding the potential neurological complications that may manifest when there is a delay in recuperation following a regional block. Timely detection and prompt intervention are essential to enhance the prognosis and facilitate a more favorable outcome and recovery(3).

Risks of Spinal Anesthesia: Complications

Complications of spinal block are frequently categorized as major and minor complications. Fortunately, most major complications are infrequent. On the other hand, minor complications are prevalent and should not be underestimated. Minor complications encompass nausea, vomiting, mild hypotension, shivering, itch, hearing impairment, and urinary retention. Post-dural puncture headache (PDPH) and unsuccessful spinal block are noteworthy and not uncommon complications associated with spinal anesthesia. Hence, we classify them as moderate complications (refer to Table 1). The failure of spinal anesthesia is reported with varying frequencies, ranging from 1% to 17%, and is further discussed in this chapter(4).

TABLE 1. Complications of spinal anesthesia(4).

Minor	Moderate	Major
• Nausea and vomiting • Mild hypotension • Shivering • Itch • Transient mild hearing impairment • Urinary retention	• Failed spinal • Postdural puncture headache	• Direct needle trauma • Infection (abscess, meningitis) • Vertebral canal hematoma • Spinal cord ischemia • Cauda equina syndrome • Arachnoiditis • Peripheral nerve injury • Total spinal anesthesia • Cardiovascular collapse • Death

Anatomy

Spinal anesthesia is accomplished by inserting a needle between the lumbar vertebrae and puncturing the dura mater to introduce anesthetic medication. Details about the structure of the skeletal spine and vertebrae are covered in a separate discussion.

In this context, we focus on the anatomy directly pertinent to the execution of spinal anesthesia.

Vertebral position: Spinal anesthesia is typically administered at a level no higher than the mid to lower lumbar vertebrae to prevent accidental puncture of the spinal cord with the needle. In the majority of patients, the spinal cord concludes at the conus medullaris, typically found at the lower margin of the first lumbar vertebral body (L1), although it may terminate at a lower point. Consequently, the spinal needle is introduced into the interspace between L3 and L4 or L4 and L5. Other interspaces, eg L2 to 3 or L5 to S1, may be less ideal; L2 to 3 is in proximity to the spinal cord, and the administration of the injection at L5 to S1 necessitates a more extensive distribution of local anesthetic (LA) to effectively anesthetize thoracic dermatomes, which is essential for certain surgical procedures. The intercristal line, denoting the line connecting the posterior superior iliac crests, serves as a general reference for the placement of the spinal needle.

Ligaments : The epidural space is the area between the dural sac and the interior of the bony spinal canal. The sturdy ligamentum flavum constitutes the rear boundary of the epidural space at each interlaminar space. The interspinous ligament extends between the spinous processes of adjacent vertebrae, and the supraspinous ligament secures the summits of the spinous processes in a continuous column.

Meninges – Inside the bony vertebral canal, the spinal cord is enveloped by three layers: the pia mater, the arachnoid mater, and the dura mater (from innermost to outermost). The dura and arachnoid maters loosely adhere to each other in the spinal canal, forming the "dural sac" that cradles the spinal cord. The subarachnoid space within the dural sac is situated between the pia and arachnoid maters and contains cerebrospinal fluid (CSF), spinal nerves, and blood vessels. A less dense trabecular network exists between the pia and the dura-arachnoid.

CSF: The central nervous system (CNS) is enveloped by cerebrospinal fluid, which is an ultrafiltrate of blood. CSF is produced continuously by the choroid plexuses and acts as a safeguard for the brain and spinal cord by providing a protective cushion. CSF flows within the spinal canal, involving both bulk movement and rhythmic oscillations.

This circulation might elucidate some of the transport of anesthetic substances toward the brain following their injection into the lumbar subarachnoid space. The density of CSF at normal body temperature averages approximately 1.0003±0.0003 g/mL, and the relative density concerning the injected local anesthetic (LA) solution impacts the distribution of spinal anesthesia.

Nerves :The dorsal and ventral spinal nerve roots emerge from the spinal cord at each vertebral level and converge to create the spinal nerves. The lumbar and sacral nerve roots extend beyond the conus medullaris, forming the cauda equina, and exit the vertebral canal between adjacent lumbar and sacral vertebrae.

A dermatome is defined as the region of skin supplied by a single spinal nerve root. The term "spinal level" indicates the uppermost dermatome anesthetized by the spinal anesthetic. The specific surgical needs are determined by the dermatome level of the skin incision and the level necessary for surgical manipulation, which may differ significantly. For instance, a lower abdominal incision during a cesarean delivery is made at the T11 to T12 dermatome, while a T4 spinal level is needed to ensure pain control during peritoneal manipulation. Sensory and visceral spinal levels required for common surgical procedures are detailed in tables(5).

Surface markers corresponding to dermatome levels include the following:

Inguinal ligament – T12

Navel (Umbilicus) – T10

Nipple – T4

Fifth finger – C8

Performance of the procedure:

This procedure is most readily executed when the lumbar spine is in full flexion. The optimal positioning can be attained by seating the patient on the surgical table with their feet placed on a stool. When they place their forearms on their thighs, they can maintain a steady and comfortable posture. Alternatively, the method can be carried out with the patient lying on their side, with their hips and knees flexed to the maximum extent.

Scrub and glove up carefully.

Inspect the instruments and supplies on the sterile cart.

Draw up the local anesthetic to be injected intra-thecally into the 5ml syringe, from the ampoule opened by your assistant. Read the label Withdraw the precise quantity you plan to utilize, making certain that your needle avoids contact with the exterior of the ampoule (which is non-sterile).

Draw up the local anesthetic to be used for skin infiltration into the 2ml syringe. Read the label carefully.

Clean the patient’s back with the swabs and antiseptic ensuring that your gloves do not touch unsterile skin .Wipe outward in a radial pattern from the intended injection site. Dispose of the swab and repeat the process multiple times, ensuring that a suitably broad area is cleansed. Let the solution air-dry on the skin.

Drape the patients back with a sterile towel to gain more freedom of movements of your hands in handling the back of your patient.

Locate a suitable inter-spinous space. In an overweight patient, you might need to apply significant pressure to detect the spinous processes.

.Inject a small volume of local anaesthetic under the skin with a disposable 25-gauge needle at the proposed puncture site.

Insert the introducer if using a 24-25 gauge needle. In an overweight patient, you might need to apply significant pressure to detect the spinous processes.

If an Epidural is intended care should be exercised in thin patients that an inadvertent dural puncture does not occur and then we are using a 18 G Epidural needles.

Insert the spinal needle (through the introducer, if applicable). Ensure that the stylet is properly positioned to prevent blunting the needle tip. It's crucial that the needle is inserted and remains in the centerline, with the bevel oriented laterally. It should be angled slightly upward (towards the head) and advanced gradually. As the needle penetrates the ligamentum flavum, you'll encounter increased resistance, followed by a release of resistance as you enter the epidural space. Another loss of resistance may be felt when the dura is punctured, and cerebrospinal fluid (CSF) should flow from the needle upon removing the stylet.

If you touch bone, retract the needle by about a centimeter and then re-advance it in a slightly more upward direction while ensuring it remains in the centerline. When using a 25-gauge spinal needle, be prepared to wait for 4 to 5 seconds for CSF to emerge after removing the stylet. If no CSF appears, reinsert the stylet, advance the needle slightly further, and attempt again.

When CSF appears, take care not to alter the position of the spinal needle as the syringe of local anaesthetic is being attached.

The needle can be most effectively stabilized by firmly placing the back of the non-dominant hand against the patient and using the thumb and index finger to grasp the needle hub. Ensure a secure attachment of the syringe to the needle hub, particularly because hyperbaric solutions are thick, and resistance during injection can be significant, especially through fine gauge needles. It's crucial to exercise caution to prevent any inadvertent spillage of the local anesthetic.

Gently aspirate to confirm that the needle tip is still intrathecal, and then slowly administer the local anesthetic. After the injection is complete, withdraw the spinal needle. introducer and syringe as one and apply a sticking plaster to the puncture site(6).

In this article, we present a succinct overview of five neurological complications associated with surgery and anesthesia. Given the extensive body of literature and the multitude of potential neurological consequences, our focus is on adverse events that are widespread (such as delirium), subject to debate (as in the case of postoperative cognitive decline, or POCD), and those with the potential for severe consequences (notably stroke, spinal cord ischemia, and postoperative visual loss, or POVL). The primary aim of this review is to acquaint practicing anesthesiologists with the prevalence, risk factors, outcomes, prevention strategies, and management of significant neurological complications, aiming to raise awareness and enhance patient care during the perioperative period.

Delirium

Delirium is an acute and fluctuating neurological condition that indicates a departure from the individual's baseline cognitive functioning. It is primarily characterized by the central features of inattention and disorganized thinking. Delirium is arguably one of the most critical postoperative complications for two main reasons:

It is highly prevalent, affecting as many as 70% of patients over the age of 60 undergoing significant inpatient surgical procedures.

It is linked to adverse consequences, including increased mortality rates, sustained cognitive decline, and prolonged stays in intensive care units and hospitals.

It's worth noting that delirium or restlessness immediately after emerging from general anesthesia is a common occurrence, particularly in children, but this discussion focuses on postoperative delirium due to its substantial impact on morbidity and mortality.

In many cases, postoperative delirium serves as an indicator of the brain's susceptibility, suggesting the potential presence of underlying neurological conditions, such as early or preclinical dementia. Despite its high occurrence and severe implications, delirium often goes undetected because it can manifest with a hypoactive phenotype, rather than the more obvious hyperactive form. Moreover, without specific inquiry, patients may appear normative or perhaps mildly lethargic. To enhance the diagnosis of delirium, reliable and easy-to-use diagnostic tools have been developed. The Confusion Assessment Method and the Confusion Assessment Method for the Intensive Care Unit (for patients unable to communicate verbally) are the most widely adopted approaches to identifying this condition(7).

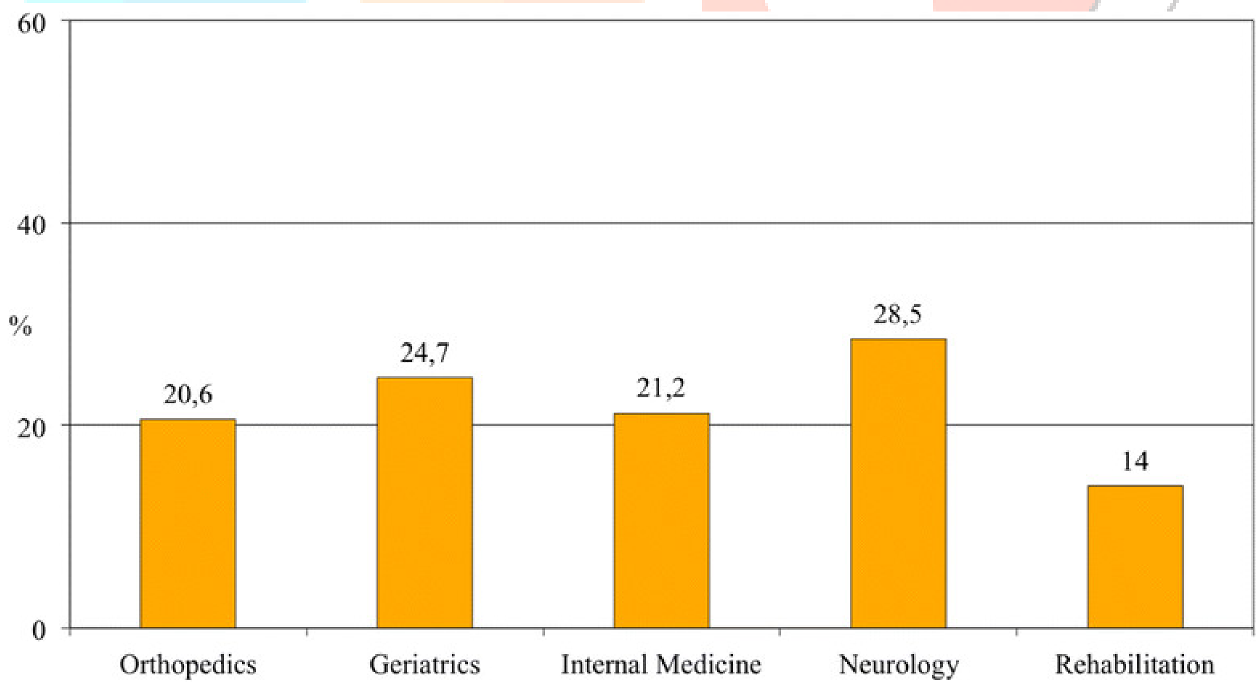

Fig 1: prevalence of delirium according to different settings(8).

Postoperative neurocognitive disorders

It is an all-encompassing term that comprises two main components: postoperative delirium, characterized by a state of acute confusion and inattention, and postoperative cognitive dysfunction (POCD), which represents a prolonged cognitive impairment primarily affecting higher-level cognitive functions and memory. While delirium and POCD were previously viewed as distinct conditions, recent data suggest a potential underlying connection between them. This connection becomes evident in patients whose brains may be vulnerable to cognitive decline following the stressors of surgery and anesthesia.

The potential mechanisms behind postoperative neurocognitive decline remain speculative but encompass factors like neuroinflammation triggered by perioperative stress, vascular disorders, or the acceleration of cognitive decline in patients with previously undiagnosed neurodegenerative conditions, such as preclinical dementia. Notably, in a study involving patients who underwent noncardiac surgery, covert stroke was identified in 7% of 1114 older patients (aged 65 and above) following surgery. This covert stroke was associated with an elevated risk of postoperative delirium and long-term cognitive deficits(9).

Postoperative Cognitive Dysfunction (POCD) in adults is characterized by an impediment in concentration, memory, language, learning, and daily functioning that arises subsequent to surgery. It can endure for weeks, months, or even more with variable degrees of severity. In many instances, cognitive dysfunction can be relatively minor and is typically identified through assessment using specific neuropsychological tests.

In the case of pediatric patients, there has been growing concern about a potential connection between long-term neurocognitive impairment and anesthesia, based on findings from both animal studies and recent clinical epidemiological investigations(10).

Stroke

As the global population continues to age, the prevalence of individuals with multiple comorbidities undergoing spine surgery has steadily risen, subsequently leading to a gradual increase in perioperative stroke incidents over time. Perioperative stroke in the context of spinal surgery is an infrequent yet catastrophic complication that constitutes a substantial contributor to morbidity(11).

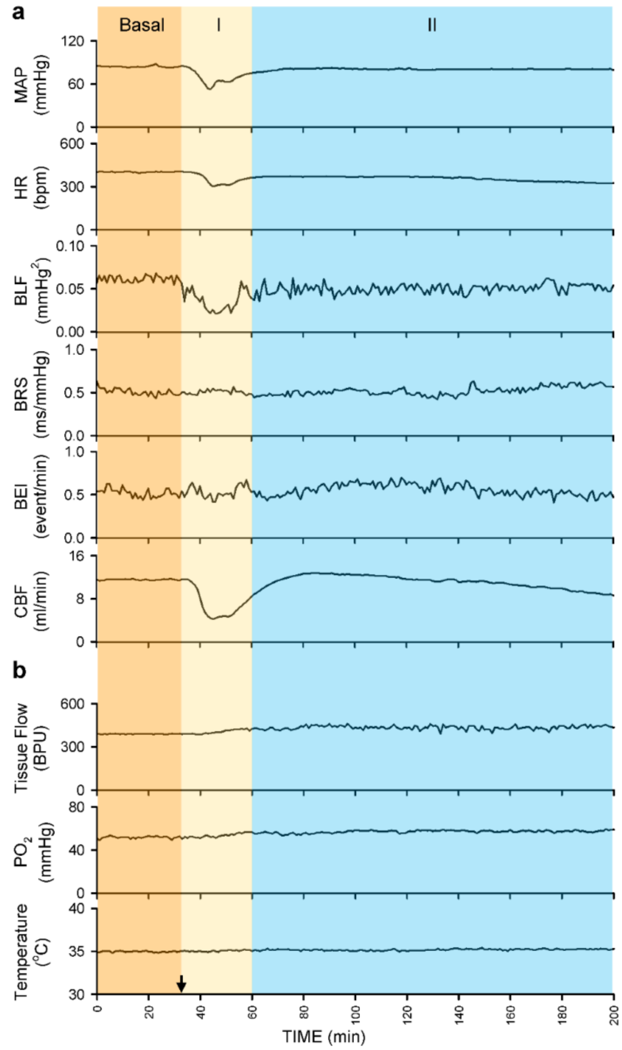

Figure 2: Illustrative examples of real-time and online recording of common phasic changes in mean arterial pressure (MAP), heart rate (HR), power density of the low-frequency component in systolic blood pressure spectrum (BLF), baroreflex sensitivity (BRS) or baroreflex effectiveness index (BEI), simultaneous with carotid blood flow (CBF) in Group 2 animals (**a**); or concurrent with tissue perfusion (Tissue Flow), tissue oxygen tension (PO_2) or tissue temperature in the cerebral cortex in Group 3 animals (**b**) on intrathecal administration of 80 μL of bupivacaine (at arrow)(12).

Hemorrhagic Stroke is a potential complication following spine and joint surgeries, such as laminectomy, lumbar spinal fusion, tumor resection, and total joint arthroplasty. While this type of stroke is rare, it can have severe consequences and is associated with a high mortality rate. The typical clinical symptoms of hemorrhagic stroke after spine and joint surgeries encompass symptoms like headache, vomiting, altered consciousness, and mental disturbances. It may manifest several hours post-surgery. Most bleeding incidents are localized in the cerebellar hemisphere and temporal lobe.

A potential causative factor for intracranial hemorrhages is cerebrospinal fluid (CSF) leakage resulting from surgical procedures. Early diagnosis and intervention play a critical role in preventing the further advancement of intracranial hemorrhages. Some patients may require hematoma evacuation, but their prognosis is often less favorable(13).

Spinal cord ischemia

We present a case of spinal cord infarction that occurred following epidural anesthesia. Instances akin to this are scarcely documented in English literature. It is important to note that spinal cord infarction is relatively rare, accounting for only 0.3–1% of stroke cases, and thus exhibits a lower incidence compared to other types of stroke.

Several studies have indicated that factors such as age, hypertension, diabetes, obesity, a history of cerebral infarction, and atherosclerotic lesions are potential risk factors for spinal cord infarction. Additionally, other investigations have explored the roles of aortic diseases and associated surgical interventions as contributing factors.

Spinal cord injuries (SCI) resulting from anesthetic procedures are infrequent occurrences but remain a significant concern for many patients undergoing surgery. The prognosis associated with anesthesia-related SCI (Anaes-SCI) is grave, and there is presumed risk of mortality. Furthermore, this type of SCI may lead to enduring effects that significantly impact the quality of life of affected individuals. Complications linked with Anaes-SCI encompass transient or permanent neurological symptoms, epidural hematoma, or abscess (often associated with irreversible neurological alterations like paresis if not diagnosed and treated promptly), direct traumatic spinal injury, and adhesive arachnoiditis. These conditions can manifest as pain (particularly back pain), paraesthesia, hypoesthesia, or even permanent anesthesia and/or motor deficits.

To avert complications, a thorough preoperative assessment and physical examination of patients are typically conducted to identify clinical conditions that heighten the risk of complications related to neuroaxis technique approaches. This can be particularly challenging for traumatic SCI patients receiving treatment in the emergency room, as they may already exhibit varying degrees of tissue damage, including meningeal and neuronal tissue laceration(14).

Postoperative visual loss

Postoperative visual loss (POVL) is an infrequent occurrence following surgical procedures, with a heightened incidence seen after cardiac, spine, head and neck, and certain orthopedic surgeries. The primary cause of postoperative ocular injury is corneal abrasion, which may or may not result in visual impairment. Notably, the most prevalent underlying factors contributing to permanent POVL include central retinal artery occlusion, ischemic optic neuropathy, and cerebral vision loss(15).

Although rare, this type of neuropathy has been acknowledged as a complication since the 1950s. However, it has received limited attention during spinal surgeries. Moreover, even more recently, there have been numerous reported cases. Many cases were reported in the 1990s, and over the course of the following two decades, there may have been an increase in occurrences.

Several factors have been suggested as potential reasons for this rarity. It may be linked to the improvement in anesthesia safety. Alternatively, it may be attributable to the assumption of enhanced visibility during procedures, the lengthier durations of more aggressive surgeries, the frequent combination of hypotensive techniques, and the growing complexity of surgical procedures. Moreover, an increasing number of older patients with higher preoperative morbidities undergoing such surgeries may contribute to a greater postoperative risk(16).

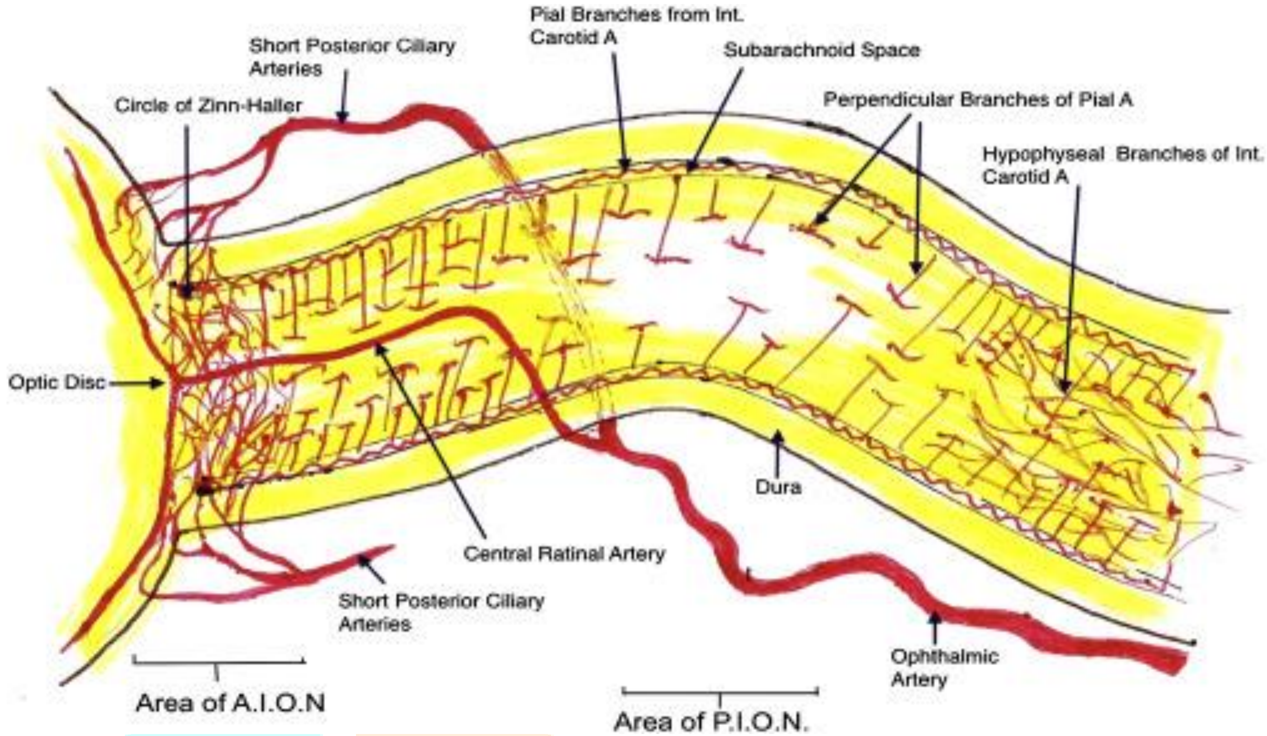

Figure 3: postoperative vision loss(17).

Conclusion

This article has explored the various factors associated with these complications, highlighting the importance of anesthetic agent choice, patient risk assessment, and proper procedural techniques. While transient neurological symptoms remain a concern . the complex landscape of postoperative complications, including postoperative vision loss, stroke, delirium, and postoperative cognitive decline, necessitates a comprehensive and multidisciplinary approach to patient care. These adverse events are multifactorial in nature and can result from a combination of patient-specific risk factors, surgical and anesthetic techniques, and postoperative management.

Addressing postoperative vision loss requires heightened awareness and proactive strategies such as meticulous positioning, vigilant monitoring, and the minimization of modifiable risk factors, like intraoperative hypotension. Stroke prevention involves optimizing patient comorbidities, meticulous surgical techniques, and close perioperative blood pressure control. Delirium and postoperative cognitive decline, often associated with elderly patients, can benefit from comprehensive preoperative assessments, optimal pain management, and early mobilization to reduce the duration and severity of these conditions.

As our understanding of these complications continues to evolve, ongoing research and clinical experience provide valuable insights into risk reduction and mitigation strategies. Healthcare providers must remain committed to enhancing patient safety, refining surgical and anesthetic techniques, and promoting interdisciplinary collaboration to reduce the incidence and severity of these postoperative complications. By doing so, we can improve patient outcomes and contribute to the overall quality of care in the field of surgery and anesthesia.

In conclusion, the realm of neurological complications following spinal anesthesia is a subject of paramount importance in the field of anesthesiology and patient care. These complications, while relatively rare, demand thorough investigation, understanding, and a vigilant approach to minimize their occurrence.

The choice of spinal anesthetic agents, meticulous patient evaluation, and precise procedural techniques play pivotal roles in the prevention of neurological complications. Advances in medical research have shed light on the intricacies of these adverse events, providing insights into risk factors and potential mitigation strategies.

As we continue to expand our knowledge and refine our practices, it is imperative that healthcare providers remain committed to the highest standards of patient safety. Ongoing research and multidisciplinary collaboration will further enhance our ability to recognize, manage, and reduce the incidence of neurological complications, ultimately ensuring better patient outcomes and upholding the quality of care within the realm of spinal anesthesia. With this concerted effort, we can strive to make spinal anesthesia even safer for patients in the years to come.

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