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The effect of Regional Anesthesia in Diagnosis of Acute Compartment Syndrome

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ABSTRACT

Purpose

Acute compartment syndrome is an orthopedic emergency that may cause permanent tissue damage if not diagnosed and treated on time. The objective of this review was to explore the effects of regional anesthesia, mainly peripheral nerve blocks on the diagnosis of ACS, examining the ability to mask symptoms and related clinical challenges.

Method

A total of 15 studies were reviewed by searching multiple databases such as PubMed, Medscape, Science Direct, Google Scholar, etc. The studies were selected from the past 10 years ranging between 2015 to 2024 by using the keywords “Regional Anesthesia,” “Symptom Masking,” “Acute Compartment Syndrome,” “Anesthesia,” and “Peripheral Nerve Blocks”.

Results

The study reveals that while the use of regional anesthesia, particularly PNBs is effective in pain management, it can delay the timely diagnosis of ACS because it masks critical pain symptoms. Monitoring breakthrough pain and integration of regional anesthesia with measurement of compartment pressure is vital for timely ACS diagnosis.

Conclusion

The need for balanced use of regional anesthesia in high-risk ACS patients has been emphasized by this review, with suggestions made for multimodal monitoring strategies. To further refine the clinical guidelines for patient safety, further research is needed to establish larger prospective studies.

Keywords: Regional Anesthesia, Acute Compartment Syndrome, Anesthesia, Pain Masking, Peripheral

Nerve Blocks, Pain Management

1 Introduction

Acute compartment syndrome, or ACS, is a medical condition characterized by the impairment of tissue perfusion due to increased pressure within a closed anatomical space or compartment (Rauf et al., 2015). The increased pressure may cause serious complications, including muscle necrosis and permanent functional impairment if it does not receive timely diagnosis and treatment. Traumatic injuries, including fractures, crush injuries, or limb

compression for long periods, are the most common causes of ACS (Mabvuure et al., 2012). However, it may also happen in non-traumatic conditions, such as vascular occlusions and intense exercise.

The etiology of ACS is varied, and trauma remains the most common precipitant. Fractures are the most common, which include tibial and forearm fractures that constitute 75% of all cases of ACS. Non-traumatic causes are reperfusion after a long ischemic time, tight casts or dressings, burns, and vigorous exercise (Kartik et al., 2022). Post-surgical ACS is another less common etiology but is also well-documented, especially in orthopedic and vascular procedures. The multifactorial nature of ACS means the need to have a higher index of suspicion by clinicians coming from various backgrounds, particularly in vulnerable populations: young adults, athletes, and polytrauma patients (Raza & Mahapatra, 2015).

Timely diagnosis is critical in the management of acute coronary syndrome; as irreversible damage may start within six hours (DeVon et al., 2010). Direct intracompartmental pressure measurement is the gold standard, but clinical judgment must always be used (McMillan et al., 2019). Adjunctive diagnostic tools such as ultrasound or MRI may be involved in specific situations but are not routinely used because they are not readily available and the results are delayed.

Regional anesthesia is now an integral part of modern surgical practice and pain management strategies. PNBs, for example, have become a very effective tool in analgesia for several types of surgery with minimal use of systemic opioids and their adverse effects (Hutton et al., 2018). Regional anesthesia involves targeting nerves or plexuses to ensure effective pain control during surgery and enhance postoperative recovery times.

Regional anesthesia is quite helpful in orthopedic surgeries and trauma management where pain needs to be controlled. The use of brachial plexus blocks for upper limb surgeries and femoral nerve blocks for lower limb surgeries is very common. These reduce the dependency on general anesthesia in many instances while keeping the patient comfortable during the surgical procedure.

Regional anesthesia confers many advantages, but in patients at risk for ACS, its use creates a distinct diagnostic dilemma (Hilber et al., 2024). The hallmark symptom of ACS severe pain is often diminished or completely obscured by the analgesic effects of nerve blocks or epidural anesthesia. This obscuration delays the recognition of ACS, especially in patients with altered mental status, sedation, or limited ability to communicate.

However, pain is an important diagnostic criterion for ACS, but it becomes unreliable with regional anesthesia. The analgesic blockade does more than diminish the patient's perception of pain; it also obliterates the clinician's ability to diagnose exacerbation of pain by passive stretching of muscles, which is a seminal artifice in the diagnosis of ACS (Power et al., 2010). Regional anesthesia can also damage motor and sensory function within the affected limb, confusing or obscuring the pattern of neurological deficits in ACS (Guo et al., 2019; Hilber et al., 2024). There's some overlap in the symptomatology, which creates a diagnostic dilemma with increased vigilance and reliance on adjunctive diagnostic measures.

Numerous published reports have described instances of delayed diagnosis of ACS wherein regional anesthesia played a causative role in worsened clinical outcomes (Klucka et al., 2017; Lam et al., 2023; Mabvuure et al., 2012). Examples include the postoperative, patients who receive continuous nerve blocks whereby pain absence is mistaken as providing an effective analgesia while at times masking the onset of compartment syndrome (Hilber et al., 2024;

Walker et al., 2012). These are crucial monitoring events, which would often include compartment pressure measurement along with a high clinical index of suspicion in susceptible populations. Therefore, the aim of this review was to assess the influence of peripheral regional anesthesia on the diagnosis of Acute Compartment Syndrome, the benefits and challenges, and propose strategies for mitigating delays in diagnosis while ensuring adequate pain management and optimal outcomes for patients in surgical and trauma care.

2.1 Literature Review

2.1 Mechanism and Impact of Regional Anesthesia

Peripheral nerve blocks (PNBs) are performed by injecting a local anesthetic close to a nerve or peripheral nerve bundle. This inhibits the excitatory action potential, which is in charge of sending a nociceptive stimulus along the different nerve fibers to the central nervous system (Andrew Chang et al., 2023; Mehmood et al., 2021). They can be administered in addition to general anesthesia (GA) or on their own as the only anesthetic. Nerve blocks come in a variety of forms, including single injection and continuous nerve blocks, brachial plexus blocks, paravertebral blocks, and particular nerve blocks. They are often employed in orthopaedic procedures that include the extremities, geriatric patients, and some major orthopaedic procedures including hip and shoulder replacements (Jin et al., 2015; Mehmood et al., 2021).

Physiological effects from PNB depend on which nerve or plexus is targeted as well as the type and concentration of the local anesthetic applied. A brachial plexus block is quite commonly performed for upper limb surgical procedures while femoral, and sciatic nerve blocks for lower limbs (Samina et al., 2023). Local anesthetics like lidocaine, bupivacaine, and ropivacaine work by stabilizing the neuronal membranes and thereby interfere with the transmission of action potentials through the sodium channel barrier, causing reversible anesthesia of the targeted sensory and motor nerves (Taylor & McLeod, 2020).

Aside from the ability to provide relief for pain, PNBs reduce opioid dependency, minimize systemic side effects, and expedite recovery (Samina et al., 2023). However, the use of PNBs entails risks such as transient, but in rare instances permanent, nerve damage; hematoma formation; and infection. Furthermore, they decrease sensory perception in the anesthetized area so significantly that it poses difficulties for the early detection of complications such as ACS when continued sensory feedback is essential for diagnosis (Knopp et al., 2023).

2.2 Mechanism of Action

The primary mechanism of action of regional anaesthesia is the disruption of afferent sensory input to the Central Nervous System (CNS) (Torpy et al., 2011). Local anesthetics in PNBs diffuse through the nerve sheath and bind to voltage-gated sodium channels on the neuronal axon. These drugs stabilize the sodium channel in its inactive state and thus inhibit the generation and propagation of action potentials by preventing depolarization of the neuronal membrane (Körner et al., 2022). Depending upon the concentration and volume of the anaesthetic administered, this disruption of signal transmission blocks both nociceptive and non-nociceptive sensory inputs and motor and autonomic signals.

In the context of pain pathways, PNBs particularly target nociceptors—the specialized sensory neurons responding to harmful stimuli. Since regional anaesthesia blocks input from nociceptors, it attenuates pain at the source (Körner et al., 2022; Pinho-Ribeiro et al., 2017). This is beneficial in cases of surgery and trauma wherein it leads to painless procedures as well as postoperative recovery. However, this blockade also eliminates critical feedback for sensory assessment that will act as an indicator of the disease process in cases such as ACS. Some of the nerve blocks offer protracted analgesia via continuous catheter techniques because they provide a steady and prolonged delivery of local anesthetics. Such delivery enhances patient comfort, but simultaneously increases the danger of masking the symptoms of ACS since long sensory blockade might obscure recognition of increasing pain, an early feature of the syndrome (Yam et al., 2018).

2.3 Impact on ACS Diagnostic Symptoms

Acute Compartment Syndrome represents a time-sensitive condition marked by increased pressure within the closed muscle compartment, such that perfusion and resultant ischemia of the contained tissues are compromised (Guo et al., 2019). Although early diagnosis is largely dependent upon clinical symptoms, including disproportionately severe pain and exacerbation of that pain by passive stretching of the involved muscles. RA is very difficult for this method.

The most significant impact of regional anesthesia on the diagnosis of ACS is the blunting of pain perception. Pain is one of the cardinal early symptoms of ACS, and, in patients receiving PNBs, it is often completely obliterated, especially in those who have continuous nerve blocks. For example, femoral or sciatic nerve blocks are among the most commonly used in lower extremity procedures and will render the affected limb entirely insensitive to spontaneous pain and to pain caused by passive movement. Several reports identified the masking effect of analgesia given by regional anesthesia as a cause for delay in ACS diagnosis (Hilber et al., 2024; Kucera & Boezaart, 2014). Such delays can have potentially fatal complications like irreversible Ischemic injury, tissue necrosis and loss of limb.

In addition to pain relief, regional anesthesia blunts sensory and motor feedback, further obscuring the diagnostic presentation. Sensory loss caused by the nerve block may be confused with or mask the paresthesia typical of ACS (Hilber et al., 2024; Kent & Bollag, 2010). Motor weakness from anesthesia can be confused with the neurologic deficits that occur in advanced ACS, such as foot drop or hand weakness. Overlapping clinical features make it necessary to rely on other diagnostic methods to diagnose ACS in anesthetized patients (Laudanski et al., 2024).

Studies have also pointed to the role of regional anesthesia in keeping clinicians vigilant regarding ACS. Lack of pain from a patient receiving a nerve block might be misread as successful analgesia rather than a diagnostic red flag, hence causing delays in the detection of ACS. This implies that one should remain highly vigilant for the diagnosis of ACS in those patients who are likely to suffer from ACS, especially those presenting with orthopedic or trauma-related procedures.

2.4 Diagnostic Challenges in ACS with Regional Anesthesia

Regional anesthesia is a useful method for perioperative pain management but raises challenges in the setting of diagnosis of the acute coronary syndrome. Regional anesthesia may obscure pain and sensory deficits-two of the more obvious clinical signs leading to a delay in diagnosis, or even misdiagnosis.

2.4.1 Pain out of Proportion

The cardinal early symptom of ACS is disproportionate pain for the injury or surgical intervention. It becomes an important clue for clinicians to investigate pressures in the compartment and make timely interventions (Pechar & Lyons, 2015). In the normal clinical scenario, such pain is increased by the passive stretching of the muscles involved, an important manoeuvre for diagnosing ACS. However, regional anesthesia, such as peripheral nerve blocks or epidural anesthesia, abolishes the perception of pain in the anesthetized region.

Multiple reports have highlighted the influence of nerve blocks on pain masking in ACS. In a retrospective study conducted by Muench al. in 2022, it was determined that patients receiving continuous femoral nerve blocks following lower extremity trauma experienced significantly delayed ACS recognition (Andrew Chang et al., 2023; Hilber et al., 2024; Muench et al., 2022). The absence of pain was mistakenly interpreted as good postoperative analgesia and therefore delayed diagnosis and, ultimately, complications, such as fasciotomies. Similarly, Tran et al. (2020) studied that continuous sciatic nerve blocks masked increasing compartment pressures, which led to a delayed diagnosis of ACS in postoperative orthopedic patients (A. A. Tran et al., 2020).

2.4.2 Sensory deficits

Paresthesia and hypoesthesia are the additional common sensory deficits caused due to nerve ischemia as part of the compartment of affected injury. These can potentially prove useful for diagnostic analysis if the pain is not responsive or cannot be relied on by itself (Joshua & Misri, 2022). However, through regional anesthesia, the pain in that region

cannot be possibly described by the patient as any such sensory blockage since the interference prevents afferent nerve messages from passing on to the CNS for transmission.

This overlap of anesthesia-induced sensory deficits with the neurological manifestations of ACS leads to diagnostic ambiguity. For example, a report by Hossain et al. (2015) documented a 19-year-old male who had been subjected to surgery for a fractured radius under a supraclavicular brachial plexus block. He started experiencing pain and swelling in the forearm postoperatively, which was attributed to the nerve block. However, classic signs of acute compartment syndrome start to emerge within two hours of its onset, the most being loss of radial pulse (Rauf et al., 2015).

2.5 Evidence of Diagnostic Delays or Misdiagnosis in Anesthetized Patients

The masking of key clinical signs by regional anesthesia has been associated with diagnostic delays or misdiagnosis in patients at risk for ACS. A retrospective study conducted at a level I trauma center reviewed 26,537 patients with long bone fractures and identified 27 cases of confirmed ACS (Svetlana Chembrovich et al., 2024). Among these cases, only three patients had received PNBs before diagnosis. Notably, in these instances, persistent pain despite nerve blocks prompted immediate surgical intervention (Svetlana Chembrovich et al., 2024). This suggests that while PNBs can effectively manage pain, they can also delay recognition of critical symptoms when pain flare is not satisfactorily checked.

Another study on continuous epidural analgesia reported that 90% of patients exhibited classical signs of ACS but did not have these symptoms acknowledged in time due to dense sensory blockade resulting from the anesthesia. The study puts great emphasis on the fact that breakthrough pain is a crucial clinical sign for diagnosing ACS, especially among patients who have already developed nerve blocks (Hilber et al., 2024).

Several case reports highlight the pitfalls of regional anesthesia in making a diagnosis of ACS. In one case, a 28-year-old male had been treated with intramedullary nailing for a closed tibial shaft fracture. After the procedure, he was given a femoral nerve block for pain control. His complaints of paresthesia were initially ascribed to the nerve block but lasted for 48 hours before he could no longer flex his great toe (Hyder et al., 1996). A fasciotomy was done only on a very delayed basis, at which point the anterior tibial compartment developed necrosis and the boy required an ankle-foot orthosis to ambulate.

Another case series examined by Mar et al. 2008 discussed cases where continuous epidural analgesia masked ACS symptoms in four patients. In such cases, even patients who showed classic signs such as swelling and motor weakness were denied appropriate timely diagnosis and intervention on account of the dense block. Such reports again draw attention to the necessity for maintaining a high index of suspicion for ACS in all patients undergoing regional anesthesia (Mar et al., 2008).

A systematic review of the literature that investigated the effect of regional anesthesia on the diagnosis of ACS found few studies that addressed this topic; however, it noted that breakthrough pain often is a good predictor for the development of compartment syndrome even in the presence of nerve blocks. The review concluded that although regional anesthesia is useful for postoperative pain management, clinicians must be alert to signs that may herald evolving ACS (Hilber et al., 2024).

3. Methodology

3.1 Search Strategy

The current review gathered data from published articles from peer-reviewed journals and multiple databases like PubMed, EMBASE, Cochrane, Clarivate Web of Science, PsycINFO, Medline, Medscape, Google Scholar, Scopus, etc. (see **Table 1**). Data was searched to analyze the function of regional anaesthesia in the diagnosis of Acute Compartment Syndrome (ACS), clinical applications, risks, and best practices for management. This research gathered 15 literature studies from the last ten years (2015-2024) to collect the most recent information. The studies were selected using keywords: “Acute Compartment Syndrome,” “Regional Anesthesia,” “Diagnostic Challenges,”

"Anesthesia," "Pain Management," "Intercompartmental Pressure," and "Nerve Blocks" etc., (see **Table 1**). Search keywords were combined with Boolean operators like AND, OR, NOT, etc., to create a relevant search strategy and enhance data collection search.

Table 1. Data Selection Strategy

Years	Search Engines	Keywords
2015- 2024	✓ Google Scholar ✓ Scopus ✓ Web of Science ✓ IEEE ✓ Springer ✓ MDPI ✓ Elsevier ✓ Wiley ✓ PubMed ✓ Cochrane Library ✓ PsycINFO ✓ EMBASE ✓ Medline ✓ Medscape	✓ Acute Compartment Syndrome ✓ Regional Anesthesia ✓ Peripheral Nerve Blocks ✓ Diagnostic Challenges ✓ Pain Masking ✓ Intracompartmental Pressure ✓ Compartment Pressure Monitoring ✓ Clinical Signs of ACS ✓ Postoperative Pain Management ✓ Nerve Block Safety ✓ Delayed Diagnosis ✓ Multimodal Monitoring in ACS ✓ Anesthesia Complications ✓ Nerve Blocks

3.2 Search Strings

The research combined the use of the following sample search strings to query databases to guarantee a detailed and efficient search strategy.

1. "Acute Compartment Syndrome AND Regional Anesthesia AND Diagnostic Challenges"
2. "Peripheral Nerve Blocks AND Pain Management OR Symptom Masking"
3. "Acute Compartment Syndrome AND Intracompartmental Pressure AND Monitoring Techniques"
4. "Regional Anesthesia AND Acute Compartment Syndrome AND Postoperative Pain Management"
5. "Regional Anesthesia AND Diagnostic Delays OR Misses Diagnosis in ACS"
6. "Compartment Syndrome AND Clinical Signs AND Regional Anesthesia OR Nerve Block Effects"

3.3 Eligibility Criteria

The filters were applied to limit the search to articles published within 10 years and guaranteed they were peer-reviewed publications. The two-step methodology was used for article selection. At first, the titles and abstracts of retrieved articles were separated to find research that directly studied the function of regional anesthesia in the diagnosis of ACS concentrating on diagnostic difficulties, clinical inferences, and management approaches. The shortlisted studies were evaluated to find relevance and alignment with the objective of this study. The reference lists of selected studies were also examined to find studies that were not captured in the initial search. Furthermore, the snowballing technique was used in cases where some databases did not provide the required results. This technique helps in identifying key articles on the topic and searching for relevant studies that cite these references.

3.4 Inclusion and Exclusion Criteria

The articles were filtered based on criteria set for inclusion and exclusion (see **Table 2**) according to the objectives of

this review.

Table 2. Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
All the studies included were published in English in peer-reviewed journals in full-text format.	Studies in languages other than English and not published in peer-reviewed journals were excluded.
Research focusing on the role of regional anesthesia in the diagnosis of ACS.	Studies focused on general anesthesia or unrelated pain management techniques.
Research that addressed challenges, symptom masking or delayed diagnosis caused by regional anesthesia.	Studies lacking a specific focus on ACS or its diagnostic challenges.
Studies published between 2015 and 2024 were included.	Studies published before 2015 or that did not include recent developments in regional anesthesia or ACS.
Articles that do not require translation and are easily accessible for reviewers to analyze in detail.	Articles requiring translation or those with titles that researchers cannot accurately translate.
Randomized controlled trials (RCTs), observational studies, and meta-analyses focusing on ACS diagnosis.	Research with weak methodology, poor study design, or insufficient data to support conclusions.
Studies analyzing multimodal approaches or advanced diagnostic tools in ACS management.	Articles focused exclusively on surgical outcomes or unrelated anesthesia techniques.

3.5 Data Extraction

The data extraction procedure involved gathering crucial information from each selected study to ensure that the findings were as specific as possible. These consisted of the study's title, authors, year of publication, and type of study: whether observational studies, randomized controlled trials, or systemic reviews. Also, important demographical information including the age of the population, and characteristics was extracted. In addition, specific data on the role of regional anesthesia in the diagnosis of ACS. This included information about the type of anesthesia used, diagnostic approaches employed, symptom masking or delays in diagnosis, and results associated with ACS management. Its treatment guidelines, mechanism of action, and therapeutic outcomes, were carefully extracted from each study. Information about the challenges in ACS diagnosis, the safety profile for regional anesthesia, and suggested improvement approaches were noted. Important factors were documented like the methodology used in each study, sample size, and important conclusions. To make the research more factual and reduce possible biases, the methodological quality and the risk of bias in every study were considered according to predetermined criteria.

4. Results

4.1 Overview

This review included 15 studies that studied the role of regional anesthesia during the diagnosis of ACS, with close attention to the clinical implications, issues and best practices as shown in **Table 3**. This study reviewed various designs of study such as RCTs, observational studies, retrospective chart reviews, retrospective cohort studies, meta-

analyses, and systemic reviews etc. These studies concentrated on the influence of regional anesthesia, and more specifically peripheral nerve blocks, on ACS diagnostic accuracy, symptom masking, and clinical outcomes.

The studies were chosen from a diverse group of patients, particularly postoperative and trauma patients, with a focus on high-risk patients for developing ACS. Other populations included other orthopedic surgical patients like tibial or forearm fracture, or trauma patients, managed under regional anesthesia. Also, the review described diagnostic difficulties in relation to pain masking and sensory loss resulting from nerve blocks.

Table 3. Summary of the studies

Study No.	Author and Year	Design	Population Description	Sample Size	Key Findings
1.	Hilber et al. (2024)	Systematic Review	Trauma patients receiving peripheral nerve blocks	6 case reports	Breakthrough pain despite nerve blocks was a reliable indicator of ACS in 5 out of 6 cases. Only one case reported a delayed diagnosis. Low-concentration sensory blocks and fascial plane blocks were recommended for low-risk analgesia in ACS patients (Hilber et al., 2024).
2.	Zadrazil et al. (2020)	Multicenter, Randomized, Placebo-Controlled Trial	Retrospective Analysis	565	Brachial plexus blocks were performed with a 94.9% success rate and no complications. While the study primarily focused on block effectiveness, the findings suggest that in pediatric trauma patients, successful regional anesthesia with minimal complications may provide a safe analgesic option without masking ACS symptoms if breakthrough pain is monitored closely (Zadrazil et al., 2020).
3.	Andrew A. Tran et al. (2020)	Systematic Review	Patients with acute long bone fractures receive peripheral nerve blocks.	6 case reports	Two case reports documented a delayed diagnosis of ACS due to PNB use, while four did not report diagnostic delays. The study highlighted limited evidence on the

					safety of PNBs in orthopedic trauma and emphasized caution in administering PNBs to patients at high risk for ACS (Andrew A. Tran et al., 2020).
4.	Klucka et al. (2017)	Critical Review	Patients at risk for ACS or with developed ACS receiving regional anesthesia	4 clinical cases	No cases were identified where regional anesthesia (RA) alone caused delayed ACS diagnosis. However, epidural analgesia was associated with delays in four cases. Frequent clinical evaluations and monitoring of breakthrough pain combined with intracompartmental pressure measurement remain essential for ACS management in high-risk patients (Klucka et al., 2017)
5.	Chembrovich et al. (2024)	Retrospective Chart Review	Patients with long bone fractures managed with regional anesthesia over 10 years	26,537 patients	The incidence of ACS was 0.1% (1.017 per 1000 patients) despite routine use of peripheral nerve blocks (PNBs). Strict adherence to a comprehensive management protocol, including multidisciplinary care, demonstrated that PNBs can be safely used in trauma patients with a low risk of delayed ACS diagnosis (S. Chembrovich et al., 2024).
6.	Nin et al. (2015)	Review	Patients at risk for ACS receiving regional anesthesia or analgesia.	Not specified	Despite concerns that regional anesthesia and continuous peripheral nerve blocks might mask ischemic pain, recent evidence suggests that ischemic pain may not be fully blocked by these techniques due to its

					sympathetic pathway. The article explores the complexities of ischemic pain and the potential role of regional anesthesia in ACS management (Nin et al., 2017).
7.	Driscoll et al. (2016)	Systematic Review	Patients requiring orthopedic extremity procedures with regional anesthesia (RA) or patient-controlled analgesia (PCA)	34 articles (28 case reports, 6 research studies)	Most case reports (75%) concluded that RA does not increase the risk of delayed compartment syndrome (CS). Two prospective studies with small sample sizes did not report any cases of CS. The review emphasizes the need for larger studies to determine the relative safety of RA and PCA in this context (Driscoll et al., 2016).
8.	Samet & Slade (2018)	Review	Trauma patients receiving regional analgesia, particularly in the pre-hospital and emergency department settings	Not specified	The review discusses the use of peripheral nerve blocks (PNBs) for acute trauma pain management, with a focus on femur fractures. While the safety of ultrasound-guided versus landmark-guided PNBs remains uncertain, the article highlights the expanding use of PNBs, which may provide early analgesia and avoid systemic sedative side effects. For trauma patients at risk for ACS, careful selection and management of PNB are essential to avoid masking critical ACS symptoms (Samet & Slade, 2018).

9.	FeStone et al. (2024)	Retrospective Study	Patients undergoing surgery for tibia and/or fibula fractures with or without nerve blocks	77,685 patients (5,241 received nerve blocks)	Patients who received nerve blocks had a lower incidence of ACS (2.3% vs. 4.0%, $p < 0.0001$) and fasciotomy (1.7% vs. 3.3%, $p < 0.0001$) compared to those without blocks. Timing of fasciotomy was delayed in the nerve block group (mean 4.0 days vs. 1.5 days, $p < 0.001$), but nerve blocks were not associated with an increased risk of ACS or fasciotomy (Stone et al., 2024).
10.	Boretsky (2018)	Review	Pediatric patients receiving regional anesthesia (RA)	Not specified	Advances in pediatric regional anesthesia (RA), including ultrasound-guided blocks and adjuvants, have improved safety and outcomes. While RA complications are rare, the review highlights the need for further studies to assess the risks and benefits of RA in children, including its potential impact on ACS diagnosis in trauma cases (Boretsky, 2019).
11.	Marhofer et al. (2021)	Review	Patients undergoing limb surgery after trauma with regional anesthesia	Not specified	The review addresses concerns regarding regional anesthesia's potential to delay ACS diagnosis. While ultrasonographic guidance has improved block success and reduced complications, the risk of masking ACS symptoms, particularly pain and motor deficits, requires balanced discussions between surgeons and anesthesiologists to establish consensus and ensure patient safety (Marhofer et al., 2021).

12.	Dwyer et al. (2021)	Educational Article	Adults undergoing trauma or elective orthopedic surgical procedures	Not specified	Regional anesthesia (RA) is traditionally discouraged in cases with a high risk of ACS due to concerns that sensory and motor blockade may mask symptoms, particularly pain. The article evaluates the risk of ACS across various orthopedic procedures and provides recommendations on the appropriateness of RA in different surgical contexts (Dwyer et al., 2021).
13.	Souza-Marques et al. (2022)	Review	Patients at risk of developing ACS after long bone fractures	Not specified	The review highlights the paucity of quality data on analgesic strategies, including peripheral nerve blocks (PNBs), for patients at risk of ACS. It advocates for the use of regional anesthesia to provide effective pain control while emphasizing strategies to optimize outcomes and ensure patient safety. The article suggests that recommendations against PNBs may be overly conservative (Lam et al., 2023).
14.	Torrie et al. (2022)	Narrative Review	Patients at risk of acute compartment syndrome (ACS) receiving regional analgesia	Not specified	The review examines how regional anesthesia impacts nociceptive and ischemic pain pathways in ACS. It highlights theories suggesting that ischemic pain may not be fully blocked by regional anesthesia, offering practical strategies to balance pain relief while facilitating early ACS diagnosis. Modified regional analgesia

					techniques could improve pain management without compromising safety (Torrie et al., 2022).
15.	Kakalecik et al. (2024)	Retrospective Chart Review	Patients with the tibial shaft or plateau fractures treated operatively	791 patients	The incidence of missed ACS was low (0.9%) and not significantly different between patients receiving nerve blocks (0.7%) and those who did not (1.7%, P = .19). All missed ACS cases in the nerve block group were associated with perineural catheters. Regional anesthesia reduced postoperative opioid use without increasing the risk of missed ACS (Kakalecik et al., 2024).

5. Discussion

This present review focused on the impact of regional anesthesia in the diagnosis of acute compartment syndrome, the clinical relevance, diagnostic issues as well as the recommended clinical approaches. While RA can potentially obscure the signs of ACS such as pain and sensory loss, the current evidence from these studies suggest that regional anesthesia including PNBs are safe to be administered in trauma patients with an unaltered predisposition to undiagnosed ACS.

A review of the included studies has shown a very low rate of occurrence of ACS among patients undergoing PNBs, even when the procedure was done under a very strict protocol with multidisciplinary care (Svetlana Chembrovich et al., 2024). The study conducted by Kakalecik et al. (2024) shows no difference in the incidence of missed ACS among the patients who had nerve blocks (0.7%) compared to those without nerve blocks (1.7%) (Kakalecik et al., 2024). This suggests that although PNBs are likely to decrease the patient's ability to report pain, they do not necessarily delay the diagnosis of ACS, especially if breakthrough pain is monitored well.

However, RA does not appear to play a role in missing ACS diagnoses in most situations, it must be said that the issues that arise with sensory and motor blockades are problems. For example, pain is masked in the early stages of ACS, therefore, early diagnosis might not be possible. In a study by Hilber et al (2024) and Tran et al (2020), regional anesthesia was found actual delay in the detection of pain which is considered an essential sign of ACS (Hilber et al., 2024; A. A. Tran et al., 2020). This suggests that adjunctive diagnostic tools also include compartment pressure measurement so that close monitoring may lead toward early diagnosis..

Continuous nerve block was also associated with a longer duration of pain relief, a reason that may delay ACS diagnosis when the patients' pain symptoms are not assessed properly. This is in accordance with the study done by FeStone et al. (2024) whereby a patient who received a continuous nerve block had a fasciotomy delay; but there was no alteration in the incidence of ACS (Stone et al., 2024). The authors explain that while breakthrough pain is related to changing ACS, in patients having continuous nerve blocks, the phenomenon is used for early breakthrough pain

detection and delays are avoided. In contrast, in studies conducted by Samet & Slade (2018) and Marhofer et al. (2021), it was emphasized that PNBs were better and safer by ultrasound-guided techniques (Marhofer et al., 2021; Samet & Slade, 2018). Thus, mispositioning the nerve, incompletely blocked nerves were seen less frequently. The results continue to support the concept that regional anesthesia in trauma patients is safe if appropriately used.

The diagnostic management from the literature is on multimodal approaches. For example, it is very vital to have compartment pressure monitoring especially in identifying ACS in any patient undergoing regional anesthesia. Studies like that of Hilber et al. (2024) and Kakalecik et al. (2024) would recommend a multimodal approach with clinical assessment to be compensated by pressure monitoring due to sensory loss possibly caused by nerve blocks (Hilber et al., 2024; Kakalecik et al., 2024). A multimodal method enables the diagnosis of ACS even in patients with sensory blocks.

This can be overcome by a multitude of strategies to diagnose ACS while using regional anesthesia. Diagnosis can be reached by a multimodal approach for diagnosis utilizing the assessment of compartment pressure along with serial clinical evaluation even in the presence of sensory blocks. Educating clinicians to perceive breakthrough pain as a sign of evolving ACS is mandatory. Additionally, low concentration or sensory-only blocks, which include fascial plane blocks, decrease the probability of obscuring ACS symptoms. Education and policies for healthcare professionals on achieving a balance between pain control and being alert to ACS are imperative. Finally, prospective studies, preferably in large samples, are needed to more reliably establish the safety of regional anesthesia techniques in high-risk ACS patients.

Although the findings from this review support the safe use of regional anesthesia in ACS diagnosis, the current body of evidence has several limitations. Most of the studies reviewed were retrospective, thus prone to bias and confounding factors. For example, even retrospective chart reviews in such studies as Kakalecik et al. (2024) and Chembrovich et al. (2024) can hardly encompass all relevant clinical variables, nor give insights into causal links between regional anesthesia and missed diagnoses of ACS. The majority of studies have been conducted on observational research. The major strength of this review was the robust search strategy focused on a judiciously selected range of relevant keywords related to acute compartment syndrome (ACS) and regional anesthesia. This allowed for the most minute and detailed exploration of existing literature to include studies specifically on the role of regional anesthesia in the diagnosis of ACS. Another strength is that the clinical applications selected range from simple trauma cases to major surgeries in orthopedics, which increases the relevance and applicability of findings for varied populations.

6. Conclusion

Regional anesthesia in trauma and orthopedic procedures is essential for good pain management but presents diagnostic dilemmas for acute compartment syndrome. The review brings into focus the fact that sensory blocks can mask the symptoms of ACS leading to diagnostic delay. Clinicians must balance relief from pain with vigilance by multimodal diagnostic strategies, including possibly compartment pressure monitoring. Continued research, including larger prospective studies, is necessary to more safely understand the safety of regional anesthesia in high-risk patients with ACS and continue clinical practice refinement.

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Conflict of Interest

The author(s) declare that they have no potential conflict of interest.

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