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Managing the Defeated Dermatome: Clinical Dilemmas, Decision-Making, and Technical Execution of Repeat Subarachnoid Blocks

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ABSTRACT

Background: Subarachnoid block (SAB), or spinal anaesthesia, is a cornerstone of modern regional anaesthesia, highly valued for its rapid onset, profound blockade, and minimal systemic drug burden across various surgical specialties. Despite its perceived simplicity, an unexpected block failure rapidly transitions a routine workflow into a high-stress scenario, imposing significant physical and psychological burdens on patients while increasing medico-legal vulnerability for the surgical team.

Objective: This article provides a comprehensive evaluation of managing failed subarachnoid blocks, detailing the underlying mechanisms of failure, clinical decision-making timelines, safe rescue execution techniques, dosage adjustments, and associated complications.

Discussion: When faced with an inadequate or absent block, anaesthesiologists must navigate limited rescue pathways, including local infiltration, systemic sedation, conversion to general anaesthesia (GA), or executing a repeat subarachnoid block. While GA serves as a reliable safety net, it introduces distinct risks-particularly in obstetric populations, such as difficult airways and gastric aspiration. Consequently, repeating the SAB emerges as a highly effective alternative. However, to safely manage and execute a repeat block, clinicians must accurately deduce the root cause of the initial failure. Spinal anaesthesia failure is a complex interplay of anatomy, physics, and pharmacology that can be categorized into three distinct clinical phases: failure to access the subarachnoid space, failure of local aesthetic distribution within the cerebrospinal fluid (CSF), and failure of drug action at the neural membranes.

Conclusion: Successfully managing a failed SAB relies on accurate phase-based troubleshooting and a precise understanding of the altered pharmacodynamic landscape before attempting a second intrathecal injection.

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Introduction

Subarachnoid block (SAB), or spinal anesthesia, stands as a cornerstone of modern regional anesthesia. Celebrated for its rapid onset, profound sensory and motor blockade, and minimal systemic drug burden, it is routinely utilized across obstetric, orthopedic, urological, and lower abdominal surgeries. However, the perceived simplicity of injecting a local anesthetic into the Cerebrospinal Fluid (CSF) space belies a complex interplay of anatomy, physics, and pharmacology.

When a subarachnoid block fails, the clinical environment rapidly transitions from a routine workflow to a high-stress scenario. Failed spinal anesthesia places a significant burden on both the patient and the surgical team, introducing risks of intraoperative pain, profound psychological distress, prolonged operating room utilization, and acute medico-legal vulnerability.

Faced with an inadequate or absent block, the anesthesiologist must rapidly evaluate a limited list of rescue pathways:

- Local infiltration supplementation by the surgical team.
- Systemic intravenous sedation and analgesia.
- Conversion to general anesthesia (GA).
- Execution of a repeat subarachnoid block.

While converting to general anesthesia is a reliable safety net, it introduces distinct risks, particularly in obstetric populations where a difficult airway, rapid oxyhemoglobin desaturation, and the risk of gastric aspiration remain persistent concerns. Consequently, repeating the subarachnoid block is a highly effective alternative, provided the clinician can accurately analyze the reasons for the initial failure and navigate the altered pharmacodynamic landscape of a second intrathecal injection.

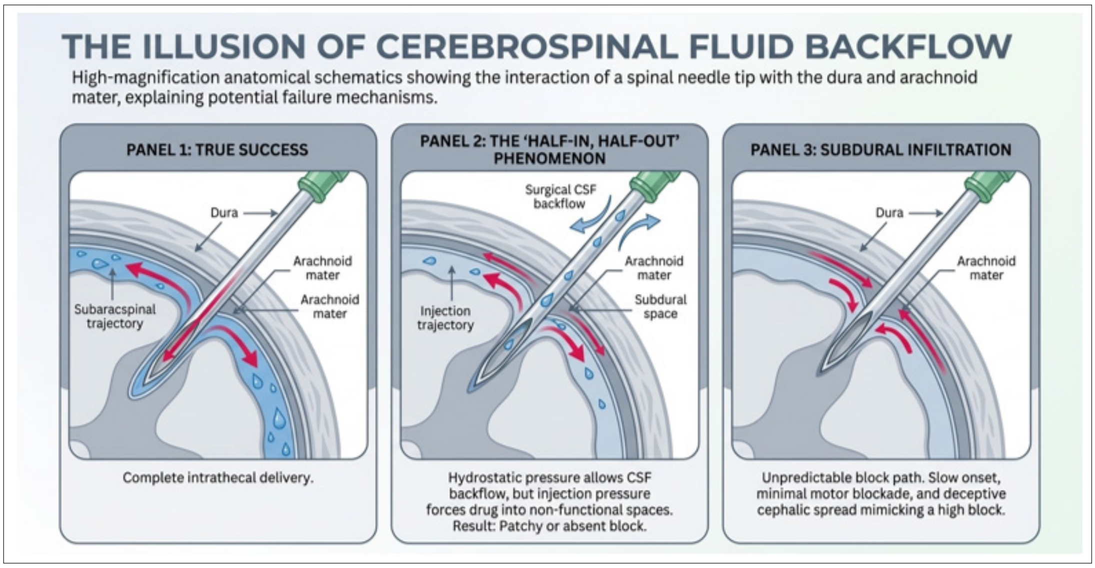
This article provides a comprehensive evaluation of managing failed subarachnoid blocks. It details the mechanisms underlying block failure, maps out the precise clinical timeline for deciding when a repeat block is appropriate, outlines safe execution techniques, analyzes ideal dosage adjustments, and examines the associated complications and risks [1].

Mechanisms and Reasons for Failure

To safely manage a failed spinal anesthetic, one must first deduce why the failure occurred. Labeling a block as simply 'failed' overlooks a spectrum of technical, pharmacological, and anatomical missteps. Clinically, failure can be categorized into three distinct phases: failure to access the subarachnoid space, failure of local anesthetic distribution within the CSF, and failure of drug action at the neural membranes.

Technical Errors and Pseudo failure

- **Needle Displacement:** The most common point of failure is technical execution. Obtaining a free flow of clear CSF is the definitive benchmark of entry into the subarachnoid space. However, achieving CSF backflow does not guarantee successful drug delivery.
- **The 'Half-In, Half-Out' Phenomenon:** The relatively long, beveled tip of a spinal needle may straddle the arachnoid mater. While CSF flows freely into the hub due to hydrostatic pressure, the actual injection pressure can push a significant portion of the anesthetic solution into the non-functional subdural space. This results in a patchy, delayed, or entirely absent block.
- **Subdural Infiltration:** The subdural space is a potential space between the dura mater and the arachnoid mater. An injection here creates an unpredictable block characterized by slow onset, patchy sensory loss, minimal motor blockade, and occasional cephalic spread that mimics a high spinal block without providing dense surgical analgesia [2].



Distribution and Anatomical Variations

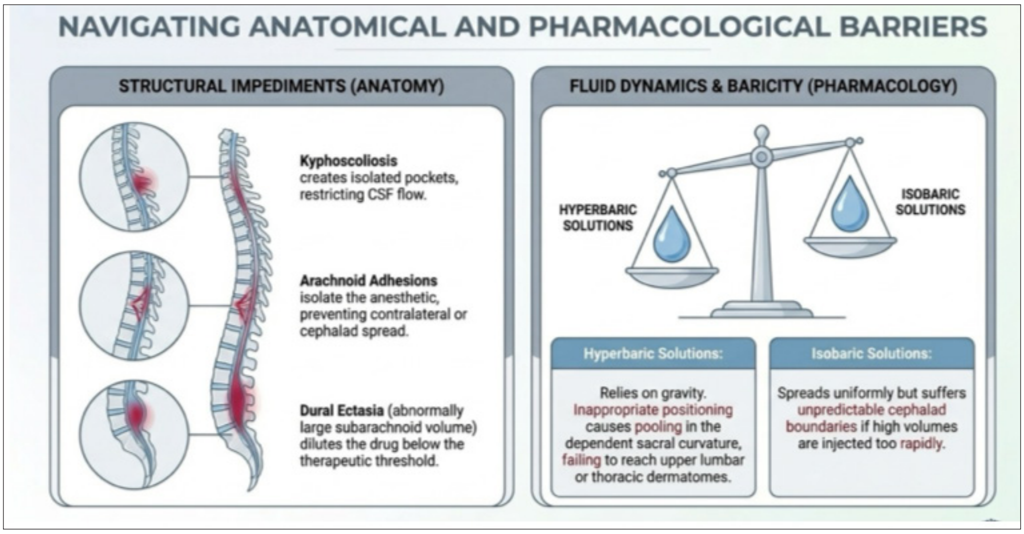
Even with proper intrathecal deposition, anatomical variation within the vertebral column can impede the predictable distribution of local anesthetics.

- **Vertebral Deformities:** Severe kyphoscoliosis, advanced lumbar lordosis, or degenerative disc disease can create isolated pockets within the subarachnoid space or restrict the normal flow of CSF.
- **Anatomical Barriers:** Longitudinal septa or arachnoid adhesions (often arising from prior spine surgeries, trauma, or silent inflammatory processes) can physically isolate the local anesthetic, preventing it from reaching the contralateral side or advancing cephalad to the desired dermatomal level.
- **Dural Ectasia:** An abnormally large subarachnoid volume, common in disorders like Marfan syndrome, can drastically dilute a standard dose of local anesthetic. This prevents the drug from reaching the critical threshold concentration required for nerve root penetration [3].

Pharmacological Factors and Formulation Anomalies

The physical behavior of the injectate inside the intrathecal space relies on its basicity-the ratio of the density of the local anesthetic solution to the density of human CSF.

- **Basicity Miscalculations:** Hyperbaric solutions (typically containing 5% to 8% dextrose) rely heavily on gravity for distribution. If a patient is placed in an inappropriate position immediately following injection, the hyperbaric solution can pool in the dependent sacral curvature, failing to ascend to upper lumbar or thoracic dermatomes. Conversely, isobaric solutions spread more uniformly but can suffer from unpredictable cephalad boundaries if high volumes are delivered too rapidly.
- **Chemical Inactivation and Sub-therapeutic Dosing:** Chemical degradation due to improper storage, though rare, can compromise drug efficacy. More frequently, failure stems from an underestimation of the required drug mass or volume for a patient's specific height, weight, or physiological state (e.g., pregnancy, which decreases the required dose due to mechanical engorgement of epidural veins reducing subarachnoid volume).

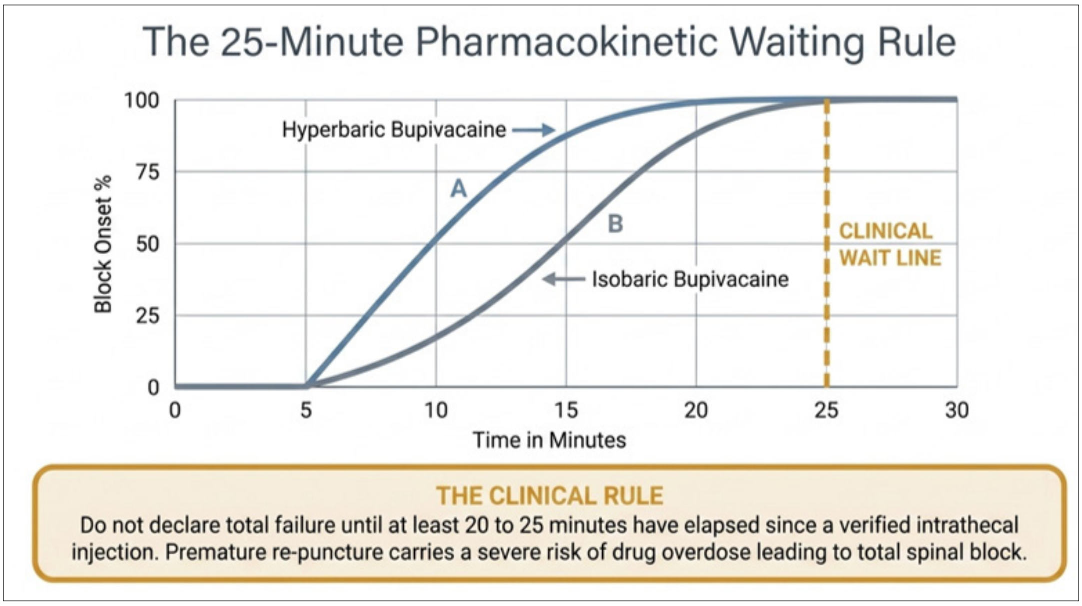


Temporal Metrics: When to Safely Repeat the Block

The decision to perform a repeat subarachnoid block requires balancing clinical patience against surgical urgency. Re-puncturing a patient prematurely carries a severe risk of drug overdose if the initial injection was merely delayed in onset, potentially leading to a dangerous total spinal block.

Defining Failure Windows

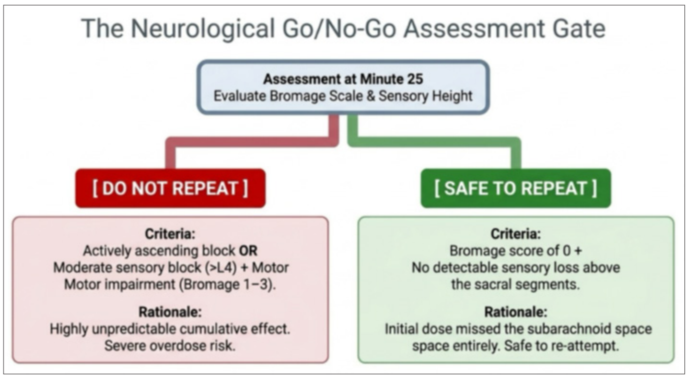
The onset kinetics of local anesthetics vary significantly based on chemical structure and formulation basicity. Hyperbaric bupivacaine typically demonstrates an onset within 5 to 10 minutes, with the final dermatomal height fixing by 15 to 20 minutes. Isobaric bupivacaine, by contrast, spreads more slowly and may require up to 25 minutes to achieve its maximum distribution [4-5].



Assessment of the Partial Block

When a block is partially successful, a detailed neurological examination is required. The anesthesiologist must systematically assess sensory height (mapping bilateral loss of temperature sensation and sharp pain perception across key landmarks) and motor density (quantifying motor block using the modified Bromage scale).

A repeat subarachnoid block is contraindicated if a partial block is actively ascending or if there is a moderate sensory block (e.g., above the L4 level) accompanied by noticeable motor impairment (Bromage 1–3). Repeating a spinal injection under these conditions introduces a highly unpredictable cumulative effect. Conversely, if 20 minutes have passed and the patient exhibits a Bromage score of 0 with no detectable sensory loss above the sacral segments, the initial dose can be assumed to have missed the space entirely, warranting a repeat attempt [6].



Technical Execution: How to Perform a Repeat Block

Executing a repeat subarachnoid block is technically distinct from performing an initial spinal anesthetic. The clinician must adapt their approach to navigate the anatomical disruption and fluid dynamics introduced by the first attempt.

Positioning Optimization

Pain, trauma from the initial attempts, or developing partial motor blocks can hinder proper patient positioning. If the patient is undergoing an orthopedic procedure for a fractured femur, positioning can be highly challenging. Adequate analgesia via careful intravenous titration of short-acting opioids (e.g., fentanyl) or a regional peripheral nerve block (e.g., a fascia iliaca compartment block) may be required to help the patient flex their lumbar spine properly.

Alterations in Interspace Selection

It is generally inadvisable to utilize the exact same vertebral interspace for a repeat attempt. The prior puncture may have induced localized tissue edema, tracking of blood, or micro-hematomas that obscure landmarks and alter the tactile feedback of the needle passing through tissues.

- If the initial attempt was low (e.g., L4-L5): Move one interspace cephalad to L3-L4, ensuring the trajectory remains well below the termination of the conus medullaris.
- If the initial attempt was higher (e.g., L3-L4): Move caudad to the L4–L5 interspace.

Shifting the interspace alters the angle of entry relative to the patient's lumbar lordosis, which helps bypass localized anatomical barriers or septa that may have compromised the first injection.

Pharmacological Strategy: Ideal Dosages for a Repeat Block

Formulating the dosage for a repeat subarachnoid block requires careful precision. The anesthesiologist must avoid a sub-therapeutic underdose, which would fail a second time, while protecting the patient from an excessive overdose. The ideal dosing strategy is directly guided by the patient's clinical response to the initial injection.

Scenario A: Complete Technical Failure (No Sensory or Motor Block)

When there is a complete absence of sensory or motor block after 20 to 25 minutes, it is highly likely that the entire initial dose was deposited into the epidural or adipose tissue. In this scenario, minimal to no local anesthetic has entered the CSF.

Dosing Recommendation: Administer 100% of the standard initial dose calculated for the surgery. For example, if a cesarean section standardly requires 11 mg to 12 mg of hyperbaric bupivacaine, the clinician can safely administer the same dose. The risk of accumulation is low because the first dose remains sequestered in the extrathecal tissues.

Scenario B: Partial or Incomplete Failure (Patchy or Low Block)

If the patient develops a low, dense block that terminates well below the surgical field, or exhibits a highly asymmetrical unilateral block, a substantial portion of the initial drug mass has successfully bound to subarachnoid nerve roots.

Dosing Recommendation: Reduce the second dose by 20% to 40% of the standard requirement. If the target dose is normally 12 mg of bupivacaine, the repeat dose should be restricted to approximately 7.5 mg to 9.5 mg. Furthermore, omit or severely restrict the use of lipophilic opioid adjuvants (such as fentanyl or morphine) in the second injection if they were included in the first.

Clinical Scenario	Suggested Agent	Recommended Dose	Rationale
Complete Failure (No changes at 25 mins)	Hyperbaric Bupivacaine 0.5%	100% of standard dose (e.g., 10-12 mg)	Initial dose assumed entirely extrathecal; zero accumulation risk inside CSF.
Partial / Low Block (Level < L4, Bromage 0)	Hyperbaric or Isobaric Bupivacaine	Reduce dose by 20% to 40% (e.g., 7.5-9.5 mg). Omit opioid adjuvants.	Residual active drug in lower segments; high risk of excessive spread.
Patchy / Unilateral Block (Sufficient on one side only)	Isobaric Bupivacaine 0.5%	Reduce dose by 30%. (Position unblocked side down).	Promotes uniform distribution across anatomical midline bar-riers without high peaks.

Complications, Risks, and Safety Management

A repeat subarachnoid block carries inherent physiological risks. Depositing a second volume of local anesthetic into the spinal canal can alter cardiovascular stability and respiratory safety.

High or Total Spinal Anesthesia

The most critical risk associated with a repeat subarachnoid block is excessive cephalad migration of the local anesthetic, leading to a high or total spinal block. This occurs when the cumulative drug mass moves up the spinal column to block the high thoracic and cervical nerve roots.

- **Pathophysiology:** When sympathetic fibers up to T4 are blocked, the cardiac accelerator fibers are inhibited, causing unopposed vagal activity that manifests as profound bradycardia and severe hypotension. If the block ascends further to involve the C3-C5 dermatomes, phrenic nerve function is compromised, leading to diaphragmatic paralysis and sudden respiratory arrest.
- **Management:** Management requires immediate intervention. The airway must be secured via endotracheal intubation, and 100% oxygen delivered mechanically. Cardiovascular collapse is managed with aggressive crystalloid fluid boluses alongside rapid administration of vasopressors and inotropes, such as phenylephrine, ephedrine, or epinephrine in severe cases [7].

Local Anesthetic Systemic Toxicity (LAST)

While intrathecal drug masses are typically too small to trigger systemic toxicity, a repeat block elevates this risk if the initial dose was accidentally injected into an epidural vein or if multiple attempts cause vascular trauma. LAST manifests as central nervous system excitation (seizures, perioral numbness, metallic taste) followed by rapid cardiovascular collapse. Management centers on maintaining the airway, suppressing seizures with benzodiazepines or propofol, and administering a 20% lipid emulsion infusion according to standard LAST protocols.

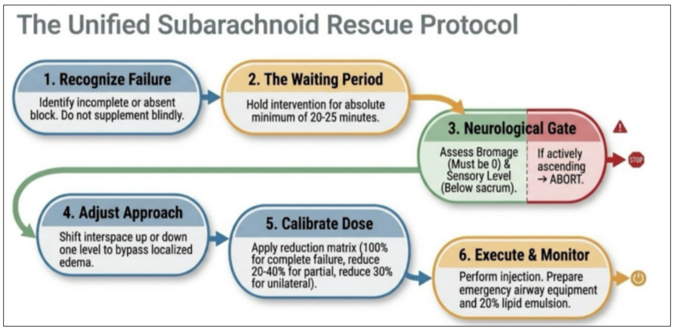
Neurological Sequelae and Tissue Injury

Repeated mechanical instrumentation of the narrow lumbar interspaces increases the risk of direct needle-induced trauma to the cauda equina or individual spinal nerve roots.

- **Paresthesias and Radiculopathy:** If a patient experiences a sharp, radiating paresthesia during needle advancement, the needle must be withdrawn immediately. Advancing or injecting local anesthetic into a nerve root can lead to permanent axonal damage and chronic radiculopathy.
- **Spinal Hematoma:** Multiple dural and vascular punctures elevate the risk of a spinal or epidural hematoma. This accumulation of blood can compress the cauda equina, creating an ischemic environment. Clinicians must closely monitor for prolonged postoperative motor blocks or new neurological deficits, which warrant urgent neurosurgical decompression [8-10].

Conclusion

The management of a failed subarachnoid block requires balancing procedural agility with careful patient safety. Success rests on an objective diagnostic process: the anesthesiologist must identify the technical or anatomical causes of the initial failure, perform a thorough neurological assessment to establish safety margins, and wait out the full pharmacodynamic timeline before attempting a second block. When properly executed with strategic adjustments to the vertebral interspace, basicity, and drug mass, a repeat subarachnoid block offers an effective alternative to general anesthesia, protecting patients from airway-related complications. However, the procedure demands heightened vigilance. Ultimately, a structured approach to repeat spinal anesthesia ensures clinical safety and high-quality intraoperative care.



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