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Perioperative antiplatelet and anticoagulant therapy in spinal cord and dorsal root ganglion stimulation evidence, guidelines, and special populations a narrative review of perioperative antithrombotic management

Terapia antiplaquetaria y anticoagulante perioperatoria en la estimulación de la médula espinal y del ganglio de la raíz dorsal evidencia, pautas y poblaciones especiales una revisión narrativa del manejo antitrombótico perioperatorio

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ABSTRACT

Perioperative management of antithrombotic, antiplatelet, and anticoagulant agents in spinal cord (SCS) or dorsal root ganglion (DRG) stimulation requires a tailored approach balancing thromboembolic risk against epidural hematoma bleeding risks.
Key Considerations:
• Assessment: Individualize risks. High vs. low thrombotic risk.
• Anticoagulant Management: Direct Oral Anticoagulants (DOACs) should be discontinued based on creatinine clearance and drug half-life (usually 48-72 hours). Vitamin K antagonists (Warfarin) need suspension and potential bridging with Low Molecular Weight Heparin (LMWH) in high-risk patients.
• Antiplatelet Management: Aspirin is often continued, but dual antiplatelet therapy (DAPT) should be managed carefully, often requiring cessation of P2Y12 inhibitors 5-7 days prior.
• Procedures: For high-risk procedures like lead placement, normalization of coagulation (INR < 1.4) is crucial.
• Reintroduction: Generally, anticoagulation can be resumed 24 hours post-procedure if bleeding is controlled.
Interruption duration depends on the specific medication, kidney function, and procedure type, with close monitoring for neurological deficits.

Keywords: Antithrombotic agents, epidural hematoma, thromboembolic risk, spinal cord stimulation, dorsal root ganglion stimulation, kidney function

RESUMEN

El manejo perioperatorio de agentes antitrombóticos, antiplaquetarios y anticoagulantes en la estimulación de la médula espinal (EME) o del ganglio de la raíz dorsal (GRD) requiere un enfoque personalizado que equilibre el riesgo tromboembólico con el riesgo de sangrado por hematoma epidural.

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Consideraciones clave:
• Evaluación: Individualizar los riesgos. Riesgo trombótico alto vs. bajo.
• Manejo anticoagulante: Los anticoagulantes orales directos (ACOD) deben suspenderse según el aclaramiento de creatinina y la vida media del fármaco (generalmente 48-72 h). Los antagonistas de la vitamina K (warfarina) deben suspenderse y, en pacientes de alto riesgo, se debe considerar la posibilidad de un puente con heparina de bajo peso molecular (HBPM).
• Manejo antiplaquetario: Con frecuencia se continúa con aspirina, pero la terapia antiplaquetaria dual (TAPD) debe manejarse con cuidado, requiriendo a menudo la suspensión de los inhibidores del P2Y12 5-7 días antes.
• Procedimientos: Para procedimientos de alto riesgo, como la colocación de electrodos, la normalización de la coagulación (INR < 1,4) es crucial.
• Reintroducción: Generalmente, la anticoagulación puede reanudarse 24 h después del procedimiento si se controla el sangrado.
La duración de la interrupción depende de la medicación específica, la función renal y el tipo de procedimiento, con una estrecha monitorización de los déficits neurológicos.

Palabras clave: Agentes antitrombóticos, hematoma epidural, riesgo tromboembólico, estimulación médula espinal, estimulación ganglio dorsal, función renal.

Introduction

Spinal cord stimulation (SCS) and dorsal root ganglion (DRG) stimulation are established treatments for patients with neuropathic pain that doesn't respond to other therapies. As these procedures have become more common, there's been a growing focus on the complications related to the procedures themselves, particularly those associated with epidural access and the permanent placement of devices. Although they are uncommon, neuraxial hematoma and infections related to medical devices are still considered serious problems. This is because they can cause permanent neurological damage and require the removal of the device[1],[5].

Managing antiplatelet and anticoagulant therapy during the perioperative period in neuromodulation procedures presents a continuing clinical challenge. Stopping antithrombotic treatment can significantly increase the risk of blood clots in patients, especially those with coronary artery disease, atrial fibrillation, or a history of strokes. Conversely, continuing these medications during epidural procedures increases the risk of bleeding in a confined space. This could also contribute to surgical site infection by promoting the formation of hematomas[1],[3],[5].

This profile of competing risks necessitates careful, individualized decision-making, rather than the use of standard protocols. The American Society of Interventional Pain Physicians currently considers spinal cord stimulation (SCS) and dorsal root ganglion (DRG) stimulation, including both trial and permanent implantation, as high-risk procedures for bleeding. They recommend specific times for stopping and restarting antiplatelet and anticoagulant medications, which depend on kidney function and blood clotting tests[1].

In contrast, the available observational data suggests that the actual risk of clinically significant bleeding during percutaneous SCS procedures might be lower than previously thought. Moeschler and his team studied a large group of patients in the past. They found no epidural hematomas or neurological problems, even in those who had recently taken aspirin or nonsteroidal anti-inflammatory drugs. However, the study might not have been large enough to find rare occurrences[2].

Simultaneously, current narrative reviews have highlighted the potential for thromboembolic complications stemming from antithrombotic interruptions to manifest more often and with more significant long-term morbidity-than the neuraxial hematomas that have been documented, thereby emphasizing the necessity of carefully weighing these risks on an individual patient basis[3].

Case reports provide additional information about patients with a very high risk of blood clots, where the usual stopping of blood-thinning medications wasn't possible. These reports suggest that carefully chosen exceptions, supported by teamwork from different fields and careful methods, might be possible. However, they also emphasize that these results shouldn't be applied to regular practice[4]. Furthermore, the Neurostimulation Appropriateness Consensus Committee's recommendations highlight that bleeding during surgery not only increases the risk of neurological problems but also plays a significant role in infections related to the device. This emphasizes the need for neuromodulation to be elective and the importance of reducing risks before the device is implanted[5].

This article is a narrative review that offers practical recommendations. It combines consensus from guidelines, observational clinical data, a narrative synthesis, examples from high-risk cases, and safety recommendations specific to neuromodulation. This study aims to critically evaluate the current evidence on antithrombotic management during surgery for SCS and DRG stimulation. We will then propose a structured, clinically useful framework. This framework will be based on a comprehensive assessment of the risks of blood clots, bleeding, and infection. Special attention will be given to patients with cardiovascular disease, diabetes, and kidney problems.

Key recommendations for antithrombotic management in SCS and DRG

1. *Treat SCS and DRG as high-impact neuraxial procedures*. Although the absolute incidence of bleeding complications is low, both spinal cord stimulation and dorsal root ganglion stimulation carry a disproportionate risk of harm if neuraxial bleeding occurs. Management decisions should therefore prioritize consequence severity rather than event frequency[1],[4].
2. *Balance thrombotic, hemorrhagic, and infectious risk in every patient.* Antithrombotic interruption may precipitate major thromboembolic events, particularly in patients with cardiovascular disease, atrial fibrillation, or recent stent

placement, while continuation increases the risk of neuraxial bleeding and device-related infection[2],[3],[5]. No single strategy is universally applicable.

3. *Aspirin should not be managed uniformly.* Aspirin discontinuation should be individualized based on indication and cardiovascular risk. Observational data suggest that limited continuation or short interruption may be reasonable in selected high-risk patients, provided procedural bleeding risk is minimized and postoperative monitoring is strict[2],[4]. Aspirin continuation should be considered an exception rather than routine practice.
4. *P2Y12 inhibitors should generally be withheld before SCS and DRG implantation.* Clopidogrel, prasugrel, ticagrelor, and ticlopidine are consistently associated with increased bleeding risk and should be temporarily discontinued prior to neuraxial neuromodulation procedures. In patients requiring ongoing antiplatelet protection, aspirin monotherapy may be maintained with cardiology input[1],[5].
5. *Direct oral anticoagulants require planned interruption with renal adjustment.* For high-risk procedures, DOACs should be held according to drug-specific pharmacokinetics, with extended interruption for dabigatran in patients with impaired renal function. Even guideline-adherent interruption does not eliminate bleeding risk, underscoring the importance of atraumatic technique and neurologic surveillance[1],[2].
6. *Warfarin management should target coagulation parameters, not fixed timelines.* For SCS and DRG implantation, warfarin should be withheld until near-normal coagulation is achieved. Bridging therapy should be reserved for select patients with very high thrombotic risk and undertaken only after multidisciplinary discussion, given its associated bleeding risk[1],[2].
7. *NSAIDs rarely mandate mandatory discontinuation but require contextual assessment.* NSAIDs alone are not consistently associated with neuraxial hematoma and may be continued or briefly withheld based on half-life, procedural complexity, and cumulative bleeding risk. Their use should be reassessed when combined with other antithrombotic agents[2],[4].
8. *Procedural technique and timing matter as much as pharmacology.* Traumatic needle placement, multiple epidural passes, or unexpected bleeding should prompt reconsideration or postponement of implantation. The risk associated with antithrombotic therapy is magnified by technical difficulty[1],[3].
9. *Neuromodulation is elective/defer implantation if risk cannot be optimized.* When antithrombotic therapy cannot be safely interrupted or modified, and bleeding or infectious risk remains unacceptably high, implantation should be deferred. This principle is central to consensus-based neuromodulation safety recommendations[3],[5].

What do current data and guidelines generally recommend regarding antithrombotic therapy in SCS and DRG?

SCS and DRG stimulation require personalized antithrombotic management. This is because, although rare, both bleeding and clotting complications can have serious consequences. The existing research consistently emphasizes the importance of risk assessment, collaborative decision,making among different specialists, and the specific clinical situation when using antiplatelet drugs, anticoagulants, and nonsteroidal anti-inflammatory drugs (NSAIDs), rather than following strict, inflexible guidelines[1],[2],[3],[4],[5].

General considerations apply to both SCS and DRG procedures, whether done as a trial or a permanent implant, are considered high-risk neuraxial interventions. This is not because complications happen often, but because the potential consequences can be very serious. Epidural space hemorrhage can cause permanent neurological damage, and perioperative bleeding has also been linked to a higher risk of device related infections[1],[5]. At the same time, stopping antithrombotic therapy has often been associated with serious thromboembolic events, such as heart attacks and strokes[2],[3].

Therefore, neuromodulation is always considered an optional treatment. If antithrombotic therapy cannot be reasonably changed or improved, the procedure should be postponed. This principle is the basis for all later recommendations regarding specific medications.

Antiplatelet agents

Aspirin

Aspirin is a particularly interesting and debated substance in the field of neuromodulation.

The existing research doesn't support a single approach to managing aspirin use. The risks of stopping aspirin depend heavily on why it's being used in the first place. If aspirin therapy is stopped, patients who take it to prevent cardiovascular problems again could face a significant risk of blood clots[2],[3].

Guidelines generally recommend temporarily stopping aspirin before high-risk neuraxial procedures, even though this recommendation is mostly based on expert agreement. 1 In contrast, observational studies of patients with percutaneous spinal cord stimulators show that many patients had procedures while taking aspirin recently or continuously, but without any reported epidural hematomas. This suggests that the actual bleeding risk might be lower than previously thought[4]. While these findings don't prove safety, they do support the selective continuation of aspirin in patients at high risk for cardiovascular issues, as long as the risk of bleeding during the procedure is minimized and postoperative monitoring is thorough[2],[4].

P2Y12 inhibitors (clopidogrel, prasugrel, ticagrelor, ticlopidine)

The use of P2Y12 inhibitors shows a higher degree of consistency. The recommend stopping these drugs before starting SCS and DRG implantation. This is due to their stronger and less predictable effects on platelets[1],[3].

A temporary cessation of antiplatelet therapy, usually spanning five to seven days contingent upon the particular agent employed, is the standard recommendation; however, aspirin is frequently retained in individuals presenting with significant cardiovascular concerns[1],[5]. The clinical scenario presented by Covert and Nobles exemplifies this strategy in a patient ex-

hibiting an elevated propensity for thrombosis, wherein clopidogrel was suspended while aspirin therapy persisted, thereby underscoring the necessity of close coordination with cardiology specialists and meticulous postoperative monitoring[5].

Anticoagulant therapy

Direct oral anticoagulants (DOACs)

DOACs including dabigatran, apixaban, rivaroxaban, and edoxaban are addressed primarily in guideline-based and narrative reviews. For high risk neuraxial procedures such as SCS and DRG implantation, temporary interruption is generally recommended, with timing adjusted according to renal function and the pharmacokinetics of each agent (Table 1)[1],[2].

Dabigatran requires careful consideration because it is removed from the body through the kidneys. Therefore, longer breaks from the medication are recommended for people with kidney problems.[1] It's also important to note that even when following guidelines for stopping the drug, the risk of bleeding isn't completely eliminated. This highlights the need for careful surgical procedures and thorough neurological evaluations after surgery[1],[2].

Vitamin K antagonists (warfarin)

The management of warfarin therapy is based on achieving acceptable coagulation parameters, rather than on set periods of interruption. For high-risk procedures, most guidelines recommend stopping warfarin until the international normalized ratio (INR) is close to normal[1],[2].

The use of heparin or low-molecular-weight heparin for bridging therapy is still a topic of debate. Although not a standard practice, this approach might be considered for certain patients who are at a very high risk of developing blood clots. However, this method also increases the risk of bleeding, so it should only be used with the agreement of a team of specialists[1].

Heparins and other parenteral anticoagulants

Unfractionated and low-molecular-weight heparins have been frequently implicated in reports of neuraxial hematoma.[1] Their use around neuromodulation procedures requires careful timing, and their presence reinforces the principle that procedural difficulty or traumatic needle placement should prompt reconsideration or postponement of implantation[1],[3].

Nonsteroidal anti-inflammatory drugs (NSAIDs)

NSAIDs are a unique group of medications, known for their generally weaker and reversible effects on how platelets work. The current research doesn't always require stopping all NSAIDs before SCS or DRG procedures[2],[4]. Instead, guidelines often use pharmacokinetic principles. They suggest temporarily stopping the drugs based on how long they stay in the body, especially when other factors that could increase bleeding are present[2].

Real-world data show that many patients have percutaneous SCS procedures after taking NSAIDs recently, and they don't have negative outcomes. However, this doesn't mean it's always safe. Therefore, NSAID use should be carefully considered, taking into account the overall risk of bleeding and the difficulty of the procedure.

Integrated clinical perspective

These sources, when considered together, advocate for a balanced, patient centered approach, rather than a strict adherence to drug specific timelines. The main recommendation goes beyond just when to stop or start a medication. It requires a careful assessment of the risk of blood clots compared to the risks of bleeding and infection in the central nervous system, considering each patient's specific situation[1],[5].

In practice, this means that patients with a high risk of blood clots might be able to keep taking certain medications for a limited time. In contrast, those with a lower risk of clots might benefit from more cautious strategies that involve stopping the medications. When the risks are too high to ignore, it's best to delay neuromodulation.

Special populations in antithrombotic management for SCS and DRG

Patients with cardiovascular disease

People with existing cardiovascular disease are often the main focus when discussing neuromodulation. This group includes people with coronary artery disease, previous heart attacks, coronary stents, atrial fibrillation, or past strokes. For these patients, antithrombotic therapy is often used to prevent further problems. Stopping this treatment can significantly increase the risk of blood clots.

Guideline-based and narrative sources both highlight the reality of thromboembolic events following the cessation of antithrombotic therapy, which can lead to permanent disability or death[1],[3]. Covert and Nobles' case report offers a specific example of this issue, detailing a patient with several coronary stents for whom the complete discontinuation of dual antiplatelet therapy was considered hazardous. In this case, aspirin was continued while clopidogrel was temporarily stopped. This highlights the idea that, in certain patients, the risk of cardiovascular problems often outweighs the risk of bleeding, as long as the procedure is carefully planned and the patient is closely monitored afterward[5].

The existing research consistently recommends that decisions about antithrombotic therapy for patients with high cardiovascular risk should not be made in isolation. It's very important to work closely with cardiology, especially for patients who have recently had a stent placed or are still taking two antiplatelet medications[1],[3]. If we can't reduce the cardiovascular risk enough, we should wait on neuromodulation, since it's a procedure that isn't always necessary[3],[5].

Patients with diabetes mellitus

Diabetes mellitus is usually discussed in relation to its effects on infection and wound healing, rather than its connection to

Table 1. Special populations table (CKD, cardiovascular, diabetes) - SCS/DRG

Drug	Pre-procedure Interruption	Post-procedure Resumption	Special population notes (CKD / cardiovascular / diabetes)	Source
Aspirin (ASA)	3-6 days before high-risk neuraxial procedures (consensus-based)	24-48 h after procedure once hemostasis is secured; continuation without interruption reported in selected patients	Cardiovascular: continuation or shorter interruption may be considered in selected high thrombotic-risk patients. Diabetes: emphasize infection risk amplification if bleeding/hematoma occurs. Renal: no specific timing adjustment stated	Narouze et al.[1]; Abd-Elsayed et al.[2]; Moeschler et al.[4]; (infection risk concept: Deer et al.[3])
Clopidogrel	5-7 days before SCS/DRG implantation	≥ 24 h after procedure (guideline-based); delayed up to 7 days post-implant in high-risk case until wound stability	Cardiovascular: in extreme thrombotic-risk case, aspirin continued while clopidogrel held; restart delayed until wound stability. Diabetes/Renal: no numeric adjustments stated	Narouze et al.[1]; Covert & Nobles[5]
Prasugrel	5-7 days before high-risk neuraxial procedures	≥ 24 h after adequate hemostasis	Cardiovascular/Diabetes/Renal: no subgroup-specific numeric adjustments stated	Narouze et al.[1]
Ticagrelor	3-5 days before high-risk neuraxial procedures	≥ 24 h after adequate hemostasis	Cardiovascular/Diabetes/Renal: no subgroup-specific numeric adjustments stated	Narouze et al.[1]
Ticlopidine	~7 days before neuraxial procedures	≥ 24 h after adequate hemostasis	Cardiovascular/Diabetes/Renal: no subgroup-specific numeric adjustments stated	Narouze et al.[1]
Dabigatran	2 days before procedure; 3-4 days if CrCl < 50 mL/min	≥ 24 h after procedure (standard); up to 48 h suggested in high bleeding-risk settings	Renal: explicit extension when CrCl < 50 mL/min. Cardiovascular/Diabetes: no additional numeric adjustment stated beyond bleeding-risk caution	Narouze et al.[1]; Abd-Elsayed et al.[2]
Apixaban	2 days before high-risk procedures	≥ 24 h after procedure; 48 h suggested for high bleeding-risk cases	Renal: "individualize/adjust in advanced CKD" is discussed at guideline level, but no additional numeric value beyond the above is provided in our five-source set. Diabetes: infection risk rises if bleeding/hematoma occurs	Narouze et al.[1]; Abd-Elsayed et al.[2][2]; (infection risk concept: Deer et al.[3])
Rivaroxaban	2 days before high-risk procedures	≥ 24 h after procedure; 48 h in higher bleeding-risk profiles	Renal: adjust/individualize in renal impairment (no additional numeric value provided here beyond the above). Diabetes: same infection-risk caution via bleeding/hematoma	Narouze et al.[1]; Abd-Elsayed et al.[2]; (infection risk concept: Deer et al.[3])
Edoxaban	2 days before high-risk neuraxial procedures	≥ 24 h after adequate hemostasis	Renal/Cardiovascular/Diabetes: no subgroup-specific numeric adjustments stated	Narouze et al.[1]
Warfarin	3-5 days before procedure to achieve INR ≈1.5 (high-risk procedures)	24 h after procedure (standard); 48 h in cases with increased bleeding concern	Cardiovascular: consider multidisciplinary input; bridging only for selected very high thrombotic-risk patients (no new numeric timing provided beyond above). Renal: no subgroup-specific numeric adjustment stated	Narouze et al.[1]; Abd-Elsayed et al.[2]
Unfractionated Heparin (UFH)	Not explicitly specified; timing emphasized due to reported neuraxial hematomas	≥ 24 h after procedure when bleeding risk is controlled	Cardiovascular: appears mainly in high-risk thrombotic settings; timing must be individualized (no specific pre-hold interval in our five sources)	Narouze et al.[1]
Low-Molecular-Weight Heparin (LMWH)	Not explicitly specified; associated with neuraxial hematoma-strict timing required	≥ 24 h after procedure; 48 h in high bleeding-risk settings	Renal: LMWH accumulation can be clinically relevant in CKD, but the five-source set here does not provide numeric CKD-specific intervals. Treat as higher bleeding-risk when renal function is reduced	Narouze et al.[1]; Abd-Elsayed et al.[2]

NSAIDs (general)	Not uniformly required; interruption based on half-life and cumulative bleeding risk	Resume same day or within 24 h as clinically indicated	Diabetes: focus on hematoma→infection linkage (optimize hemostasis). Renal: NSAIDs carry non-hemostatic renal risk, but no SCS/DRG timing modifications are provided in our five sources	Abd-Elsayed et al.[2]; Moeschler et al.[4]; (infection risk concept: Deer et al.[3])
Ibuprofen	Continued or ≤ 24 h interruption reported	Resume immediately or within 24 h	Renal: no numeric timing guidance in these sources; consider renal safety separately	Moeschler et al.[4]
Naproxen	~4 days before procedure (half-life based)	Resume within 24 h	Renal/Diabetes/Cardiovascular: no subgroup-specific timing stated	Abd-Elsayed et al.[2]
Meloxicam	~4 days before procedure (half-life based)	Resume within 24 h	Renal/Diabetes/Cardiovascular: no subgroup-specific timing stated	Abd-Elsayed et al.[2]
Ketorolac	~24 h before procedure when bleeding risk is a concern	Resume after 24 h if hemostasis is adequate	Renal: renal safety concerns exist generally, but no SCS/DRG timing modifications are provided in this five-source set	Abd-Elsayed et al.[2]

thrombosis. The North American Clinical Consensus (NACC) guidelines identify diabetes as a standalone risk factor for surgical site infections and device-related complications within the context of neuromodulation[3]. Furthermore, perioperative bleeding and the subsequent formation of hematomas could exacerbate the risk of infection in diabetic individuals, potentially through the promotion of tissue hypoxia and the proliferation of bacteria.

In practice, people with diabetes often have several risk factors that overlap, such as blood vessel problems, kidney issues, and the long-term use of medications to prevent blood clots. While the studies examined do not offer diabetes-specific antithrombotic schedules, the existing body of research uniformly advocates for a more cautious strategy within this demographic. This approach underscores the importance of careful hemostatic management, the optimization of glycemic control, and increased postoperative monitoring[3],[5].

Therefore, in people with diabetes, the decision to continue or stop antithrombotic treatment should consider not only the risks of bleeding and blood clots, but also the potential effects of bleeding on the risk of infection. This could be the most important clinical problem for these patients.

Patients with chronic kidney disease

Guidelines specifically address chronic kidney disease (CKD), particularly regarding the use of DOACs. Reduced kidney function changes how the body processes several blood-thinning drugs, particularly dabigatran. This results in a longer anticoagulant effect and a higher risk of bleeding[1],[2].

The ASIPP guidelines and narrative reviews consistently recommend longer pauses in dabigatran treatment for patients with reduced kidney function. They also advise caution when using other DOACs in advanced CKD[1],[2]. In addition to how the body processes the drugs, CKD is linked to problems with platelets and a type of blood clotting disorder caused by uremia, which makes it harder to assess the risks. Therefore, for patients with kidney disease, standard interruption schedules might not be enough. Instead, a personalized approach, considering kidney function, how drugs are cleared, and the specific risks of the procedure, is essential. In uncertain situations, it's recommended to use a cautious approach to timing and to include input from different fields[1],[2].

Other populations discussed in the literature

Beyond the three groups above, the reviewed literature implicitly identifies additional populations that warrant heightened caution, even if they are not addressed as standalone categories:

- *Patients with prior spine surgery or spinal stenosis*: in whom the epidural space may be anatomically compromised, increasing susceptibility to neurologic injury from even small hematomas[1],[2].
- *Patients requiring bridging anticoagulation*: who often represent a subset with very high thrombotic risk; the literature cautions that bridging itself may increase bleeding risk and should be reserved for select cases[1].
- *Patients undergoing permanent implantation rather than trial procedures*: as longer procedural time, tunneling, and pocket creation may increase bleeding and infection risk compared with percutaneous trials[3],[5].

Assessing thrombotic versus neuraxial hematoma risk: The core clinical decision

The perioperative management of antithrombotic therapy in SCS and DRG stimulation requires balancing two competing, but unequal, risks. These risks are thromboembolic events that can happen if the therapy is stopped, and neuraxial hematoma, which can occur if anticoagulation or antiplatelet medications are continued. Although both complications are rare, their consequences can be severe, permanent, and, in some cases, life-threatening[1],[5].

The risk of thrombosis should be primarily assessed based on the reason for and timing of antithrombotic treatment. Patients who take anticoagulants or antiplatelet drugs to prevent further problems, like those who have recently had a coronary stent, have atrial fibrillation with a high risk of stroke, have had a heart attack before, or have had a recent stroke face a significantly higher risk of negative outcomes if their treatment is stopped.

Narrative and guideline-based sources consistently emphasize that thromboembolic complications following interruption are not merely theoretical and may lead to more long term problems than the neuraxial bleeding events that have been reported[1],[3]. Therefore, in these patients, the threshold for stopping therapy should be higher, and decisions should be made collaboratively with the prescribing specialist. In contrast, the risk of a hematoma in the neuraxial space is less related to the medications used and more to the specific procedures and the person's anatomy.

Traumatic needle placement, multiple epidural passes, altered spinal anatomy, prior spine surgery, spinal stenosis, and the presence of indwelling leads during permanent implantation are all factors that can contribute to complications[1],[3]. Although observational data indicate that the absolute incidence of clinically significant hematoma in percutaneous SCS procedures is infrequent, even a small hematoma within the epidural space can precipitate catastrophic neurological injury if diagnosis or decompression is delayed[4]. Therefore, the clinical impact of bleeding risk is disproportionately high, notwithstanding its low frequency.

Importantly, existing research highlights that the risk of bleeding goes beyond just neurological damage. Hematoma formation during the perioperative period has been implicated in the development of device-related infections, as it fosters both tissue ischemia and bacterial proliferation; this is especially pertinent in populations at heightened risk, including those with diabetes mellitus[3]. Consequently, this interplay exacerbates the ramifications of bleeding, thereby underscoring the critical importance of precise hemostatic techniques and vigilant postoperative monitoring. From a unified perspective, the risk of thrombosis is usually systemic and based on probability, while the risk of hematoma is localized and determined by the specific consequences.

The first factor is mainly determined by the patient's other health conditions and the reason for the treatment. In contrast, the second factor depends on how the procedure is done and the specific anatomical features. Therefore, management decisions shouldn't be based solely on the specific interruption times for each drug. Instead, they should include a thorough assessment of the patient's risk of blood clots, the risk of bleeding related to the procedure, and the possibility of balancing both.

If the risk of thrombosis is too high and antithrombotic treatment can't be safely changed, neuromodulation, which is an elective procedure, should be postponed[3],[5]. On the other hand, if the risk of bleeding can be reduced by using careful techniques, limiting the number of needle insertions, and carefully timing when to stop medications, implantation might be a reasonable choice, even for patients who are already on long-term antithrombotic therapy. In all situations, quickly recognizing neurological symptoms and providing immediate access to imaging and surgical decompression are crucial protective measures.

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