Anticoagulation in Elective Spine Surgery: A Narrative Review of Reported Guidelines and Current Literature

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Learning Objectives: After participating in this CME activity, the spine surgeon should be better able to:
1. Describe the mechanism of action and cessation times of common anticoagulant medications used in patients undergoing elective spine surgery.
2. Interpret recommendations in the literature and institutional guidelines for use of anticoagulant medications in spine surgery.
3. Explain the risk of postoperative venous thromboembolism (VTE) after various spine procedures and strategies for mechanical and chemoprophylactic prevention of VTE.

Key Words: Anticoagulation, Deep vein thrombosis, Venous thromboembolism

The management of anticoagulatory medications is a common problem in patients undergoing elective spine surgery for degenerative pathologies. Given the aging population in the United States, and the increasing burden of cardiovascular disease, this problem is becoming more common in elective surgery. A difficult balance must be achieved between maintaining adequate operative hemostasis while avoiding thromboembolic events in patients with cardiovascular comorbidities. Outside of elective surgery at large, spine surgery is in a unique position. Irrespective of the generally high bleeding risk associated with these procedures, the bleeding complications associated with spine surgery (e.g., epidural hematoma) can lead to devastating neurovascular outcomes dreaded by surgeons. Therefore, the appropriately timed cessation of these medications is crucial; however, a concise set of clinical guidelines by spine surgery societies has yet to be created.

Furthermore, outside of the population of patients on chronic anticoagulatory medications, the risk of venous thromboembolism (VTE) in the form of deep vein thromboses (DVT) and potentially pulmonary embolisms (PE) is high in orthopedic surgery. In spine surgery alone, the rates of PE have been reported to range from 0.6% to 18%; however, the
Although previous studies have commonly excluded from this literature search. Popular reports a large percentage of surgeons who deemed aspirin to be a perioperative thrombotic therapy in spine surgery. The North American Association of Spine Surgeons (NASS) has issued its Antithrombotic Therapies in Spine Surgery in 2009 detailing their clinical guidelines regarding anticoagulatory cessation in spine surgery. While failing to differentiate dose-dependent protocols for aspirin, it was their recommendation that although ASA cessation should be specific to the individual agent’s pharmacokinetic properties, stopping ASA “approximately one week prior to spine surgery seems prudent.” It should be worth noting that as of 2021, NASS has issued a call to update their clinical practice guidelines; however, recent literature surveying a series of German spine surgeons, and those within the United States, have come to the agreement that even low-dose aspirin should be held 7 days before surgery. It is worth noting not only did this German survey report a large percentage of surgeons who deemed aspirin to be a perioperative risk factor, but several additional studies note a large practice variation in aspirin cessation supporting the need for further guidelines.

The objective of this review is to synthesize major institutional guidelines, from societies either related or external to spine surgery, describing the cessation timepoints of common anticoagulatory medications: aspirin, warfarin, and direct oral anticoagulants (DOACs). Furthermore, this review will differentiate between high and low VTE risk surgeries and identify the literary support for common mechanical and chemoprophylactic VTE management strategies in elective spine surgery. This review will be largely limited to adult patients undergoing elective spine surgery; oncologic and trauma patients were generally excluded from this literature search.

Aspirin

Aminosalicylic acid (ASA), referred to commonly as aspirin, is a commonly used antiplatelet medication in patients with notable risk of cardiovascular disease. Aspirin irreversibly inhibits the cyclo-oxygenase 1 (COX-1) enzyme, blocking the production of thromboxane A2, and other prostaglandins, preventing a critical step in platelet production of thrombin, and ultimately a platelet-thrombin plug. As a noncompetitive, irreversible COX-1 inhibitor, the regenerative time of platelets becomes of note in the perioperative management of spine surgery patients. Although previous studies have noted a regenerative timepoint of approximately 10 days, this is dependent upon various patient demographics: age, comorbidities, etc. Given the prevalence of aspirin in the population of patients undergoing elective spine surgery for degenerative pathology, an important question arises as to the institutional guidelines regarding its management.

Unfortunately, few guidelines have been issued by societal organizations describing clear clinical practice guidelines for these medications in spine surgery. The North American Association of Spine Surgeons (NASS) has issued its Antithrombotic Therapies in Spine Surgery in 2009 detailing their clinical guidelines regarding anticoagulatory cessation in spine surgery. While failing to differentiate dose-dependent protocols for aspirin, it was their recommendation that although ASA cessation should be specific to the individual agent’s pharmacokinetic properties, stopping ASA “approximately one week prior to spine surgery seems prudent.” It should be worth noting that as of 2021, NASS has issued a call to update their clinical practice guidelines; however, recent literature surveying a series of German spine surgeons, and those within the United States, has come to the agreement that even low-dose aspirin should be held 7 days before surgery. It is worth noting not only did this German survey report a large percentage of surgeons who deemed aspirin to be a perioperative risk factor, but several additional studies note a large practice variation in aspirin cessation supporting the need for further guidelines.
In 2014, the American College of Cardiology and American Heart Association (ACC/AHA) issued its Guideline on Perioperative Cardiovascular Evaluation and Management of Patients Undergoing Noncardiac Surgery. In brief, for patients undergoing noncardiac surgery and taking aspirin for primary prevention, ASA may be discontinued; however, patients without a cardiac stent taking aspirin for secondary prevention should continue this medication.9 The ACC/AHA issued a statement describing individual patient risk stratification for patients determinant upon the threat of cardiovascular complication compared with that of bleeding and made these clinical recommendations based on the results of several non-spine-related randomized controlled trials, including STRATEGEM10 and POISE-2.11 Although patients undergoing spine surgery for trauma or oncological cases are largely out of the scope of this review, it is worth noting the risk for aspirin withdrawal syndrome, particularly in highly coagulable patients.11 Although this phenomenon is not fully understood, it is believed that differential enzymatic responses to aspirin between patients generate a rapid return of platelets dependent upon the time of aspirin cessation, which increases the risk of cardiovascular incident.

The clinical practice guidelines of the ACC/AHA are largely general to noncardiac surgery and suggest the referral to a cardiologist when in doubt. To address spine-specific concerns surrounding perioperative VTE, a panel of spine surgeons, internal medicine physicians, and hematologists took part in the International Consensus Meeting on Venous Thromboembolism (ICM-VTE). The ICM-VTE made a recommendation that low-dose aspirin (81–500 mg) should be held 1 to 3 days before surgery, high-dose aspirin (>1 g) should be held at least 7 days before surgery, and that aspirin may be continued in the event of an extensive cardiac history.14 These guidelines have been deemed lenient by some suggesting the role of epidural hematoma has not been fully investigated in these cases;15,16 The ICM-VTE consensus was made based upon the recommendations of the American Society of Regional Anesthesia and Pain Management (ASRA) and several randomized controlled trial studies, some of which suggest an increased bleeding risk if even low-dose aspirin is halted within a week of surgery.17–19 Several recent meta-analyses and systematic reviews investigating the role of aspirin in spine surgery have largely reported it not to be a risk factor for complications and perioperative bleeding; however, these studies have admittedly been underpowered and generally consist of low-level evidence (ie, retrospective case series).20–22

Warfarin

Warfarin is a vitamin K epoxide reductase inhibitor, preventing the activation of clotting factors II, VII, IX, and X and protein C and protein S, thereby blocking the coagulation cascade.6,23 Although institutional guidelines vary, a general recommendation of stopping warfarin 5 days before spine surgery has generally been observed.16 Although simplified guidelines may assist in preoperative clearance efficiency, warfarin is noted as difficult to dose with a large interpatient variability dependent on several patient-specific factors (eg, age). Major institutional guidelines include that of a 2018 International Consensus Meeting (ICM) supporting the 5-day preoperative cessation of warfarin; however, they further noted that an international normalized ratio (INR) of 1.4 is acceptable but 1.2 or less is more adequate.24 The more restrictive variant of these guidelines is advised by the ASRA suggesting that a 5- to 6-day period of preoperative cessation of warfarin is necessary before spinal intervention and that INR should normalize in these patients, (ie, an INR ≤1.2).4 It is worth noting that the ASRA is more focused on spinal interventional procedures for pain management as opposed to spine surgery; however, in the presence of major spine institutional guidelines they are frequently cited. In the case of elevated INR before spinal surgery, several warfarin reversal agents exist: vitamin K (oral or IV), fresh frozen plasma, and prothrombin complex concentrate (PCC); however, the time to activation ranges from 24 hours after administration (oral vitamin K) to instant (PCC).25,26 There is a large gap in the spine literature regarding INR normalization in spinal surgery patients. One retrospective cohort study of 18 patients undergoing emergent spine surgery demonstrated that administration of PCC an average of 4 hours before surgery decreased INRs from an average of 2.27 ± 1.20 to 1.12 ± 0.10 and was deemed generally safe from a bleeding and thrombotic standpoint.27

As evidenced by 2 recent literature reviews, the role of perioperative management surrounding warfarin is extremely limited within spine surgery.28–29 The interpractice variation regarding warfarin management in spine surgery has been largely unexplored; however, it is worth noting the previously mentioned survey study of 20 US spine surgeons did come to an agreement regarding a 5-day period of cessation for warfarin; however, they failed to mention any INR goals.6 Of the extremely limited current research on warfarin management in spine surgery patients, one of the most cited studies was conducted by Young et al.29 In this study, 263 patients undergoing lumbar fusion and/or decompression for degenerative spine pathology were retrospectively investigated to determine the role of warfarin on operative blood loss, transfusions, and postoperative epidural hematomas. This study excluded patients on any additional anticoagulants and objectively measured operative blood loss via cell saver. Although patients in the warfarin cessation group demonstrated a statistically similar preoperative INR to the warfarin naïve group, they had significantly greater intraoperative blood loss (839 ± 790 mL vs 441 ± 384 mL) and statistically greater rates of postoperative transfusions (23.1% vs 7.4%). Although the only 2 postoperative hematomas and the 1 epidural hematoma in the study were all noted in the warfarin naïve group, the warfarin cessation cohort consisted of only 5% of the total study sample limiting the power and generalizability of these findings.

An additional study frequently cited by ASRA guidelines investigating a retrospective cohort of 23 patients analyzed the activity of clotting factors.30 Before undergoing spinal injection, these patients held warfarin 5 days before intervention and had their INR measured to confirm a value of 1.2 or less. The endpoint of this study was a 40% or more activity of coagulation factors as deemed adequate for hemostasis by several historic studies.31,32 Benzon et al concluded of the 21/23 patients who achieved an INR of
1.2 or less, 95% had clotting factor activities 40% or more suggesting that an INR goal of 1.2 is sufficient; however, the range of INR 1.2 to 1.4 could not be sufficiently analyzed.

**Direct Oral Anticoagulant Medications**

A newer anticoagulant class of medications, DOACs, contains the following medications: rivaroxaban, apixaban, and dabigatran. Dabigatran is a direct thrombin (CF II) inhibitor, and apixaban and rivaroxaban are direct factor Xa inhibitors (Xais). These medications are advantageous for their shorter half-lives compared with traditional agents (eg, warfarin and aspirin); however, only within the last few years have reversal agents been developed, which are still experimental, expensive, and not easily accessible. Thus in the absence of major spine surgery institutional guidelines, the perioperative management of these agents must be advised based on expert consensus and studies investigating bleeding risk factors across elective procedures. It is worth noting that although yet to be released, the NASS update to its 2009 predecessor *Antithrombotics in Spine Surgery* will include DOACs and Xais in their new search criteria.

At the time of this review, no spine surgery society has issued a set of clinical practice guidelines for the perioperative management of Xais and DOACs. A recent survey-based study analyzing the practice patterns of AO Spine, Cervical Spine Research and Society (CSRS), and Lumbar Spine Research Society (LSRS) members demonstrated a great discrepancy in the management ranging from holding medications 2 days before surgery to 1 week before surgery. Although the previously addressed Delphi study of 20 US spine surgeons came to a consensus of holding DOACs 2 days before spine surgery, both of these studies fail to make any evidence-based claims using evidence within the literature. The closest set of regulatory strategies comes from ASRA, which generalized their recommendations to start and stop DOACs surrounding spine interventional procedures based solely on pharmacokinetics. General recommendations were made to halt the use of DOACs approximately 4 to 5 drug half-lives before intervention (ie, pausing dabigatran 4 days prior, rivaroxaban 3 days prior, and apixaban 3 days before spine pain interventional procedures), while restarting agents approximately 24 hours after the procedure. Although a general trend of pausing these agents 2 to 3 days before surgical intervention and restarting them the following day has been reported by several review articles, these pharmacokinetic guidelines fail to account for the altered half-life of DOACs due to compromised kidney function.

More recent protocols have been developed based upon kidney function-dependent drug half-lives stratifying the period of cessation based on the specific DOAC, a high versus low procedural risk of bleeding, and a creatinine clearance determined kidney function categorized as high (>50 mL/min), moderate (30–50 mL/min), and low (≤30 mL/min).

Within these guidelines for high-risk surgery, dabigatran is recommended to be held 2 to 5 or more days prior, rivaroxaban is recommended to be held 2 to 3 days prior, and apixaban is recommended to be held 2 to 3 days before surgery. It is worth noting that this DOAC perioperative management strategy has been built on the results of patients in various randomized clinical trials such as the RE-LY and ROCKET-AF trials in which a subset of patients being treated with various new DOAC medications required surgery. Unfortunately, these trials were not focused on the assessment of managing these medications surrounding the perioperative period and were often underpowered concerning their number of patients undergoing procedures with a high bleeding risk or if they even included patients undergoing spine surgery.

Since the RE-LY and ROCKET-AF guidelines were established, the completed Perioperative Anticoagulation Use for Surgery Evaluation (PAUSE) study has been published. This management strategy was generally tested as patients with low kidney function (CrCl ≤30) were excluded, and for high bleeding risk procedures, apixaban and rivaroxaban were held 48 hours before the procedure. Dabigatran was held for high-risk procedures for 2 or 4 days before surgery depending on a kidney function threshold of 50 mL/min. The results of the PAUSE literature found these guidelines safe regarding a preestablished arterial thromboembolic cutoff of 1.5%; however, regarding the high-risk procedures, both apixaban and rivaroxaban exceeded the major bleeding risk cutoff of 2% at 2.96% and 2.95%, respectively. Although subsequent analyses have found hypertension and prior bleeding to be significant for major bleeding during the PAUSE trial, a separate study demonstrated that in the apixaban group only, perceived procedural bleeding risk significantly predicted major bleeding events.

Although the DOAC management strategy tested in the PAUSE trial has generally been accepted as safe, these studies have not accounted for the unique risks of spine surgery patients (eg, epidural hematoma). Studies surrounding the management of Xais and DOACs at large are extremely limited in the spine surgery literature. Presently, only one retrospective cohort study exists in which a wide range of DOAC discontinuation and recontinuation patterns were assessed for surgical bleeding and thrombotic events in patients who underwent a variety of cervical and lumbar procedures at a single institution. Croci et al concluded from this trial that DOAC discontinuation less than 24 hours before surgery was associated with increased transfusions and worse kidney function was associated with postoperative anemia. Furthermore, all thrombotic events occurred in those who restarted DOACs more than 72 hours after surgery. Although these results largely support the previously established criteria, the current paucity of DOAC management literature focused on patients undergoing spine surgery limits their generalizability and further emphasizes the need for surgical spine society guidelines.

**Mechanical and Chemoprophylactic VTE Management**

Outside of the patients on long-term anticoagulatory medications before needing spine surgery, there is a large debate as to the necessity of and strategies for VTE prophylaxis. In the 2009 NASS Antithrombotics in Spine Surgery, strategies such as mechanical and chemoprophylaxis (heparin) are discussed; however, no specific recommendations are made as to the timing of these agents and for what procedures or patient conditions necessitate them. The
previously mentioned 2018 ICM-VTE guidelines determined the following spinal surgeries as high VTE risk: tumor, trauma, infection, multiple staged or combined approach procedures, lumbar fusions involving long constructs or anterior approaches, and posterior cervical fusions; low VTE risk procedures included pediatric surgery, microdisectomies, anterior cervical discectomy and fusions (ACDFs), and cervical and lumbar decompressions based on a thorough literature review. Outside of this expert consensus, a 2015 review article developed an algorithmic approach to VTE prophylaxis based on a similar set of surgical risk factors, and neurologic risk of bleeding, and a set of patient risk factors (eg, history of VTE, trauma, malignancy, and spinal cord injury). Based on the sum of these risks, minimal strategies such as sequential compressive devices (SCD) to more aggressive chemoprophylaxis including heparin for VTE management have been indicated. Although a 2020 survey of AO Spine members generally demonstrated a preference toward SCD and early mobilization before using heparin, the question is raised as to support in the literature surrounding elective spine surgery for these protocols.

Mechanical VTE prophylaxis (ie, early mobilization and SCDs) offers a low-risk alternative to chemoprophylaxis in a population of patients where the risk of postoperative bleeding is often too high. It is worth noting that isolated mechanical VTE prophylaxis is often ignored in the literature; however, some smaller case reports can be found. For example, in a single institution study, approximately 2000 spinal surgery patients were separated into a cohort with no mechanical prophylaxis and a separate group of patients who underwent early ambulation (≤3 days in decompressions and ≤7 days in fusions). The results of this study demonstrated a significantly higher rate of PE as determined by CT scan in the nonmechanical prophylaxis group (1.5% vs 0.2%). Following this several studies have compared early mobilization and SCDs with or without the addition of heparin and have largely demonstrated an additional benefit of this chemoprophylaxis in lower rates of VTE development.

An interesting area of future research would be the rates of symptomatic and/or nonsymptomatic VTE in patients undergoing isolated mechanical prophylaxis in minimally invasive spine procedures.

Despite being mentioned in NASS’s 2009 antithrombotic guidelines, heparin, either unfractioned or low-molecular-weight heparin (LMWH), remains a common chemoprophylactic agent for VTEs. Single institutional studies and case series of patients undergoing elective spine surgery generally have demonstrated the safety of LMWH on postoperative day 1 with regard to a low risk of hematoma and bleeding complications and a low incidence of VTEs; however, there is presently a gap in the literature comparing LMWH to placebo in a spine surgery-specific population.

### Table 1. Summary of Anticoagulation Guidelines

<table>
<thead>
<tr>
<th>Source</th>
<th>Year</th>
<th>Anticoagulation Guidelines</th>
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<tr>
<td><strong>Aspirin</strong></td>
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<tr>
<td>NASS</td>
<td>2009</td>
<td>Aspirin may be stopped ~1 wk before surgery</td>
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| ACC/AHA                 | 2014     | Noncardiac surgery, primary prevention: discontinue aspirin  
Noncardiac surgery, secondary prevention, no cardiac stent: may continue aspirin |
| ICM-VTE                 | 2022     | Low-dose ASA (81–500 mg): hold 1–3 d before spine surgery  
High-dose ASA (>1 g): hold ≥7 d before spine surgery  
*Patients with extensive cardiac history may continue ASA* |
| **Warfarin**            |          |                            |
| International Consensus Meeting | 2018 | Stop warfarin 5 d preoperatively  
INR goal of 1.4 is acceptable, but ≤1.2 is more adequate |
| ASRA                    | 2017     | Stop warfarin 5–6 d before spine pain intervention  
INR goal ≤1.2 |
| **DOAC**                |          |                            |
| ASRA                    | 2017     | Dabigatran: stop 4 d before spine pain intervention  
Rivaroxaban: stop 3 d before spine pain intervention  
Apixaban: stop 3 d before spine pain intervention |
| Anderson et al[36]      | 2014     | For high bleeding risk procedures: |
| Creatinine Clearance (mL/min) | Dabigatran | Rivaroxaban | Apixaban |
| >50                     | 1 d      | 1 d      | 1 d      |
| 30–50                   | 2 d      | 1 d      | 2 d      |
| 15–30                   | 2–5 d    | 2 d      | 2 d      |

ACC/AHA, American College of Cardiology and American Heart Association; ASA, aminosalicylic acid; ASRA, American Society of Regional Anesthesia and Pain Management; DOAC, direct oral anticoagulant; ICM-VTE, International Consensus Meeting on Venous Thromboembolism; INR, international normalized ratio; NASS, North American Association of Spine Surgeons.
Despite this, larger insurance and quality improvement database studies generally have failed to demonstrate the superiority of LMWH in VTE prophylaxis. For example, a recent Premier database study investigated the role of the aspirin, unfractioned heparin, and LMWH when given day of surgery on VTE and hematoma development.\textsuperscript{57} Fiasconaro et al\textsuperscript{57} determined that LMWH had statistically similar rates of VTE and hematoma compared with unfractioned heparin and aspirin; however, LMWH was associated with lower rates of transfusion compared with regular heparin. A separate study using National Surgical Quality Improvement Program Database (NSQIP) and a subset of 2855 single institution spine surgery patients demonstrated that unfractioned heparin did not change the rate of VTE in elective spine surgery patients but did increase the rate of epidural hematomas significantly.\textsuperscript{46} In sum, this generally highlights the need for specifically designed and powered studies investigating the role of heparin as a VTE chemoprophylactic agent to clarify these relationships until further guidelines are developed.

While more contemporary, the short half-lives of common DOAC agents lend well to potential VTE chemoprophylaxis in spine surgery. Their use in spine surgery has been largely motivated by the success within the joint arthroplasty literature, as was evidenced by the RE-MOBILIZE trials.\textsuperscript{58} Recent trials have begun comparing rivaroxaban to various heparin agents. One trial of 262 patients undergoing instrumented spinal fusion for a variety of conditions (eg, tumor, trauma, and degenerative conditions) demonstrated no significant differences between rivaroxaban and enoxaparin in VTEs or epidural hematomas.\textsuperscript{59} The safety of rivaroxaban was largely confirmed in a randomized trial comparing the agent to pamparin in the case of lumbar spine surgery patients, in which VTE and bleeding rates were found to be similar between groups.\textsuperscript{60}

In one final single-center report comparing apixaban to rivaroxaban, patients were randomized into groups and began treatment on postoperative day 1, continuing the medication for 2 weeks after surgery.\textsuperscript{61} Although Zhang et al\textsuperscript{61} reported no differences in thromboembolic events between groups, the apixaban group demonstrated lower bleeding. These results suggest DOACs may offer a safe method of chemoprophylaxis to traditional agents (ie, heparin) and require further study to best determine relevant clinical guidelines.

**Conclusion**

Until updated NASS clinical practice guidelines are published detailing perioperative anticoagulatory medication management and appropriate VTE prophylaxis, these topics must be managed as part of an interdisciplinary approach between spine surgeons, cardiologists, and intern medicine physicians. Presently, there is a paucity in the spine surgery literature surrounding the management of patients on chronic anticoagulatory medications and VTE prophylaxis in spine surgery. A summary of the literature reported in this article may be found in Table 1. Given the high risk of bleeding and their potentially devastating complications in spine surgery, more randomized controlled trials are required to assess the safety and efficacy of these protocols.

**Practice Pearls**

- It is generally accepted that high-dose aspirin (≥1 g) should be stopped 7 days or more before spine surgery whereas low-dose aspirin (81 mg) may be held 1 to 3 days prior.
- Warfarin should be stopped 5 days or more before spine surgery and a patient’s INR must be 1.4 or less; however, an INR of 1.2 or less is more appropriate for higher bleeding risk procedures.
- DOACs should be stopped at least 2 to 3 days before spine surgery dependent on patient kidney function.
- Generally high VTE risk spine procedures include trauma, oncology, large posterior lumbar fusions, anterior lumbar fusions, and posterior cervical fusions.
- VTE prophylactic strategies vary; however, SCDs and early ambulation are common and safe methods of mechanical prophylaxis. LMWH remains a common chemoprophylactic agent despite mixed evidence.

**References**

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1. Which one of the following spine surgery societies is working on an update to its anticoagulation management guidelines?
   A. NASS
   B. AO Spine
   C. LRS
   D. ISASS

2. Which of the following supports continuing low-dose aspirin throughout the operative period if a patient has an extensive cardiac history?
   A. ACC/AHA
   B. ICM-VTE
   C. several recent meta-analyses
   D. all of the above

3. According to guidelines issued by a 2018 International Consensus Meeting (ICM), an acceptable INR goal and an ideal INR goal, respectively, for patients taking warfarin and undergoing spine surgery are
   A. ≤1.6, ≤1.2
   B. ≤1.4, ≤1.2
   C. ≤1.6, ≤1.4
   D. none of the above

4. Regarding the study by Croci et al, which is the sole focused study on DOAC management in spinal surgery patients to date, at what point did DOAC discontinuation before surgery lead to increased rates of transfusions?
   A. ≤24 hours
   B. ≤48 hours
   C. ≤72 hours
   D. ≤96 hours

5. Which one of the following anticoagulation medication is associated with a rebound hypercoagulability syndrome, leading to increased thromboembolic risk when restarting the medication?
   A. clopidogrel
   B. warfarin
   C. aspirin
   D. apixaban

6. In the orthopedic surgery literature, the use of DOACs for VTE prophylaxis, specifically Xa inhibitors, originated from
   A. arthroplasty
   B. spine
   C. foot and ankle
   D. none of the above

7. With regard to postoperative VTE, the higher-risk spine surgery on the basis of the current consensus and literature is
   A. decompression
   B. ACDF
   C. PCDF
   D. pediatrics

8. Which one of the following anticoagulation medications or classes has a half-life highly influenced by kidney function, calling for some to make kidney function-specific guidelines?
   A. aspirin
   B. warfarin
   C. DOACs
   D. clopidogrel

9. The lowest risk form of VTE prophylaxis advised by the 2009 NASS anticoagulation guidelines is
   A. heparin
   B. warfarin
   C. aspirin
   D. SCDs and early walking

10. In the only elective spine surgery study focused on warfarin management, stopping warfarin 5 days before surgery demonstrated a similar rate of bleeding compared with the warfarin naïve cohort.
    A. true
    B. false