

predict the individual who will finish first. That's a lot harder to predict. I have had people ask when they finish early if they were the first; I sometimes say "yes" to more than one of them as they leave because I'm empathetic and it seems so important somehow to their egos.

I also have yet, in this session, to have the inevitable complaint that these test questions do, in fact, stink, and the complainer would be happy to supply us with the correct answers to the inappropriate or just plain poor-quality questions. I don't know for sure, but I'd bet those guys are usually going to be the ones to not pass the test, somehow.

Correction: I just now received that specific complaint. Now I can relax. The remedy I offer the complaining individual is to have them document their concerns, in pencil (no pens allowed, please, and no scissors or belts in the test environment) on the feedback sheet, which is guaranteed to be eyeballed by the authorities after the test is in the can. I hope this is actually true. I have seen several pages of specifics handed in by one person in a past session, which was somewhat of a record. Most diplomates are content to get out of here as fast as possible and are just glad to get it over with. Most of these folks will pass this test anyway and forget about it for another 10 years.

Although I can only personally vouch for the neuroradiology COQ/MOC, I thought the test itself was pretty well done, fair and balanced, and actually a learning experience. This is because when I went home and looked up some of the things I saw on the test, I found I was sometimes wrong (yes, it happens) and I actually learned the right answer. Belatedly, but I still passed.

By now you have undoubtedly heard about the infamous "true or false" questions, right? When I took the test as one of the first responders 2 years ago, neither the ABR as tester nor I as tested knew these questions constituted a minefield that would continue to be a danger for future diplomates even when warned specifically to look out for them. In brief, "T or F" questions typically have 4 or 5 choices as answers, each with a "T" and an "F" box in front. It is honest-to-goodness complete human nature to only bother the check off the "T's" and leave the "F's" blank. You cannot help yourself. The only problem is that an "F" left unchecked will be counted as incorrect. I didn't figure that out until halfway through 42 questions when I first took the test. To compound the problem, many of these are "blocked" so that once they are left, the test-taker can go back and look at them, and scream, but cannot change them in any way. Bummer, but I still passed the examination (must have done really well on the spine questions). Word to the wise, but I'll bet you're still going to do this to at least one of these questions when you take the test.

All right, now. It's almost over for this session and I only have 2 more sessions to go tomorrow. The CAQ is obviously an important certification to have, and to maintain; it may be even more important in the future, if hospital privileges or reimbursements ever require them. As much of a pain as all this rigmarole is, you should support it and go get tested. It has actually been very heartening to see some of the giants of neuroradiology, in their seventh and eighth decades, being tortured at the test centers along with the younger generation. Since I am one of those old guys, I guess I'm glad I set an example, griping and moaning all the way. I'm also real glad I

actually did pass the test, given how much I screwed up the true or false questions.

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COMMENTARY

Recommendations for Anticoagulated Patients Undergoing Image-Guided Spinal Procedures

Anticoagulated patients often need image-guided spinal procedures for CSF harvest, myelography, vertebroplasty, vertebral biopsies, or epidural injections. The risk of spinal hematoma is increased in anticoagulated patients who undergo lumbar puncture or neuraxial anesthesia. Any procedure involving needle manipulation or biopsy with potential transgression of the subarachnoid, subdural, or epidural vasculature, however, likely carries a similar risk. This risk is increased, often substantially, by the use of multiple anticoagulants and the intensity of anticoagulation. It is crucial that radiologists who perform spinal procedures be familiar with the common anticoagulant and antiplatelet medications.

Radiologists are increasingly being asked to provide fluoroscopically assisted access to the neuraxial system. Whether a routine lumbar puncture, epidural steroid injection, spinal biopsy, or the more unusual C1–2 cervical puncture, there is the potential for bleeding complications. Most of the case reports involving spinal hematomas following lumbar puncture, high cervical myelogram, and epidural injection (as well as those related to neuraxial anesthesia) are reported in the anesthesia and surgical literature.^{1–4} Large series consistently note that the risk of spinal hematoma is potentiated by the concomitant administration of anticoagulant and/or antiplatelet therapy and difficult and/or traumatic spinal instrumentation.^{5,6} Neurologic compromise typically presents as a sensory or motor deficit or bowel/bladder dysfunction, not severe radicular back pain. Because of delays in the diagnosis, neurologic recovery is poor in most cases. Thus, radiologists must be aware of the risk factors and diagnosis of spinal bleeding.

Much of the information related to postprocedure spinal hematomas in anticoagulated patients is derived from cases of spinal hematoma associated with neuraxial anesthesia and anesthesia. Formal recommendations have been put forth by the American Society of Regional Anesthesia and Pain Medicine, but correlative recommendations by the radiology community are currently not available.⁷ In hopes of facilitating the management of patients presenting to radiologists for spinal procedures in the setting of anticoagulant or antiplatelet therapy, we offer a focused, readily accessible set of guidelines for performing spinal procedures on anticoagulated patients.

Discussion

Literature is available regarding recommendations for managing patients with medication-induced coagulopathies and is reviewed below (Table). Patients typically receive these medications for chronic antithrombotic therapy in the prevention

Recommended guidelines for performing spinal procedures in anticoagulated patients

Warfarin	Discontinue chronic warfarin therapy 4–5 days before spinal procedure and evaluate INR. INR should be within the normal range at time of procedure to ensure adequate levels of all vitamin K-dependent factors.
Antiplatelet medications	No contraindications with aspirin or NSAIDs. Thienopyridine derivatives (clopidogrel and ticlopidine) should be discontinued 7 days and 14 days, respectively, prior to procedure. GP IIb/IIIa inhibitors should be discontinued to allow recovery of platelet function prior to procedure (8 hours for tirofiban and eptifibatide, 24–48 hours for abciximab).
Thrombolytics/fibrinolytics	There are no available data to suggest a safe interval between procedure and initiation or discontinuation of these medications. Follow fibrinogen level and observe for signs of neural compression.
LMWH	Delay procedure at least 12 hours from the last dose of thromboprophylaxis LMWH dose. For “treatment” dosing of LMWH, at least 24 hours should elapse prior to procedure. LMWH should not be administered within 24 hours after the procedure.
Unfractionated SQ heparin	There are no contraindications to neuraxial procedure if total daily dose is less than 10,000 units. For higher dosing regimens, manage according to intravenous heparin guidelines.
Unfractionated IV heparin	Delay spinal puncture 2–4 hours after last dose, document normal aPTT. Heparin may be restarted 1 hour following procedure.

Note:—NSAIDs indicates nonsteroidal antiinflammatory drugs; GP IIb/IIIa, platelet glycoprotein receptor IIb/IIIa inhibitors; INR, international normalized ratio; LMWH, low-molecular-weight heparin; aPTT, activated partial thromboplastin time. *Adapted from:* Horlocker TT, Wedel DJ, Benzon H, et al. **Regional anesthesia in the anticoagulated patient: defining the risks (the second ASRA Consensus Conference on Neuraxial Anesthesia and Anticoagulation).** *Reg Anesth Pain Med* 2003;28:172–97.

of stroke or myocardial ischemia, thromboprophylaxis following surgery, or treatment of acute thromboembolism or coronary syndrome. The intensity and duration of anticoagulation affect the risk of spontaneous, as well as procedural-related spinal bleeding.⁸ Although less common than needle placement for injection or biopsy, radiologists may also be requested to assist with placement of an indwelling neuraxial catheter, such as a spinal drainage catheter. In these cases, significant anticoagulant medications should *not* be administered until the catheter or drain is removed.

Anticoagulant Therapy

Warfarin. Chronic warfarin therapy increases the risk of spinal hematoma following lumbar puncture. The addition of agents that affect different parts of the clotting mechanism likely increase the risk for spinal hematoma and do so without further elevation of the prothrombin time (PT) or international normalized ratio (INR).⁹ These medications include heparin, nonsteroidal anti-inflammatory drugs (NSAIDs), and antiplatelet agents. Warfarin should be discontinued in anticipation of the spinal procedure and normalization of the INR documented preprocedure. If a spinal procedure is performed on a patient with an INR >1.2, close neurologic testing of motor and sensory function should be performed for at least 24 hours to ensure prompt recognition and treatment of spinal hematoma. In emergent cases, the injection of vitamin K or transfusion of fresh frozen plasma may counteract the effects of warfarin.¹⁰

Heparin. There is no contraindication to spinal puncture in patients receiving subcutaneous heparin as a prophylaxis for deep venous thrombosis providing the total dose is <10,000 U.¹¹ Higher dosing may result in sustained prolongation of the activated partial thromboplastin time (aPTT). These patients are managed similar to those who are systemically heparinized. Delaying the scheduled heparin injection until after the puncture may reduce the risk of spinal hematoma. The risk of bleeding is likely increased in debilitated patients on prolonged therapy. Patients receiving heparin for longer than 4 days need to have a platelet count assessment because of the potential for heparin-induced thrombocytopenia.¹²

Systemic heparinization represents an increased risk for

spinal bleeding.⁸ Heparin infusion should be discontinued and aPTT normalized before the procedure. A subsequent dose of intravenous heparin should not be administered for at least an hour after the procedure.^{11,13} The combined use of other anticoagulants with unfractionated heparin may increase the risk of spinal hematoma. These include antiplatelets, low-molecular-weight heparin (LMWH), and oral anticoagulants.

LMWH. LMWH is the recommended thromboprophylactic agent following major orthopedic and general surgical procedures.¹⁴ It is important that there be a number of dosing regimens for LMWH, including low-dose (thromboprophylactic) and high-dose (therapeutic) applications. There are many pharmacologic differences between standard unfractionated heparin and LMWH, including prolonged half-life and irreversibility with protamine.^{15,16} Early postoperative dosing, twice-daily dosing, and traumatic needle placement were identified as risk factors for spinal hematoma associated with neuraxial anesthesia. Because significant anticoagulant activity persists for 12 hours after low-dose injection (and 24 hours for a high-dose injection), these time intervals should be observed before a spinal procedure. Likewise, the first post-procedural LMWH dose should be administered 18–24 hours later, to allow for adequate hemostasis.

Thrombolytic Therapy

Data are not available to clearly define how long spinal puncture should be avoided following termination of thrombolytic/fibrinolytic therapy; however, significant defects in hemostasis are present for longer than 24 hours. Patients who have recently had or that are likely to receive thrombolytic/fibrinolytic therapy should be warned against receiving a spinal puncture except in very unusual circumstances. Likewise, patients should be questioned before starting thrombolytic/fibrinolytic therapy whether there has been a recent spinal procedure such as lumbar puncture. This will allow for appropriate monitoring in cases where the drug must be administered. Original guidelines recommended avoidance of thrombolytic drugs for 10 days following puncture of noncompressible vessels.¹⁷ In certain cases, measurement of fibrinogen level (one of the last clotting factors to recover) may be helpful in monitoring a patient who underwent or will undergo a spinal procedure.⁷

Antiplatelet Therapy

The antiplatelet medications include a diverse group of agents in terms of their effects on platelet function; therefore, it is not possible to extrapolate between the various groups of drugs regarding spinal procedures. These agents include NSAIDs, thienopyridine derivatives, and GP IIb/IIIa antagonists.

NSAIDs

The use of NSAIDs alone does not seem to increase the risk of spinal hematoma from spinal puncture. At this time, there do not seem to be specific concerns related to timing of spinal puncture in relation to the dosing of NSAIDs or postprocedure monitoring.^{18,19}

Thienopyridine Derivatives

This class of antiplatelet agents works by inhibiting adenosine diphosphate–induced platelet aggregation. These drugs affect both primary and secondary platelet aggregation as well as platelet-fibrinogen binding.²⁰ The agents in this class include clopidogrel (Plavix) and ticlopidine (Ticlid). The patient should be carefully assessed for other factors that might lead to bleeding such as easy bruising/bleeding, female sex, and increased age.⁷ The addition of other medications affecting different clotting mechanisms will likely increase the chance for spinal hematoma.

GP IIb/IIIa–Receptor Antagonists

These agents affect platelet-fibrinogen and platelet–von Willebrand factor binding to inhibit platelet aggregation. These medications are often given concomitantly with aspirin and heparin. This class of antiplatelet drugs includes abciximab (ReoPro), eptifibatid (Integrilin), and tirofiban (Aggrastat). Normal platelet aggregation is usually achieved 8 hours after discontinuation of tirofiban and eptifibatid and 24–48 hours after discontinuing abciximab.

The true risk of spinal hematoma in patients on thienopyridine derivatives or GP IIb/IIIa antagonists is unknown. Management is based on labeling precautions and prior experience. The concomitant use of aspirin with these agents may increase the risk for spinal hematoma. The GP IIa/IIIb antagonists have a profound effect on platelet aggregation and spinal puncture should be avoided until platelet function has recovered.²¹ Of note, these agents are contraindicated within 4 weeks of surgery. There is not a definitive test, including bleed-time, that can guide antiplatelet therapy.

Conclusion

The increased vigilance over venous thromboembolism and introduction of more efficacious antiplatelet agents has introduced a degree of complexity into the performance of spinal procedures. The presence and continued evolution of antiplatelet agents, various heparin derivatives and thrombolytic therapy requires a thorough investigation of a patient's med-

ication history. Continued surveillance of the literature will be necessary to stay abreast of the newer agents that are sure to appear, as well as any changes in the recommendations regarding agents currently in use. The guidelines referenced in the table and can be accessed on-line at www.asra.com.

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