erroneous. One milligram heparin has contained 130 units of heparin at least since the Second International Standardization in 1968.[2,5] More recently, after contamination issues, the Food and Drug Administration and U.S. Pharmacopeia have mandated a new reference standard for heparin, and 1 mg heparin now contains not less than 180 units.[6,7] We do not think this change in heparin formulation is recognized widely and hence advocating heparin use in milligram may lead to a variable interpretation and dosing.

Furthermore, the Society of Thoracic Surgeons and Society of Cardiac Anesthesiologists Practice Guidelines for Blood Transfusion and Conservation in Cardiac Surgery (2007, updated in 2011)[8,9] have recommend using either a low-dose protamine protocol (50% of heparin dose) or a titrated protamine dose guided by activated clotting time response testing to neutralize heparinization in the postcardiopulmonary bypass patient. Although the evidence in favor is not strong, we wonder if adherence to above guidelines may have impacted the data presented.

Advances in technology such as point-of-care coagulation testing should be embraced in a timely manner, but we must acknowledge that age-old drugs such as heparin and protamine have not yet been evaluated systematically in cardiac surgery.

Competing Interests

The authors declare no competing interests.

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In Reply:

We appreciate the letter by Bulatovic and Taneja on our study[1] and agree that it would have been more accurate to state heparin dose in units rather than in milligrams in our algorithm. We also agree that heparin management, which encompasses heparin dosing, monitoring of effect, and reversal with protamine, is an important component of cardiac surgery that is incompletely understood and requires further investigation. Given that our algorithm was not aimed at optimizing or even modifying heparin management, we made no attempts to alter or audit heparin management practice. The milligram to milligram representation of the protamine to heparin dose is consistent with a low-dose protamine practice.[2] Because heparin management at our institution was not altered with protocol implementation, this is not likely to have had an impact on our results.

Our algorithm was aimed at optimizing coagulation management by incorporation of point-of-care coagulation testing into routine practice, and the results suggest that we succeeded in reducing transfusions and some adverse outcomes. We are looking forward to the results of our large, multicenter study to see whether our findings are generalizable (ClinicalTrials.gov Identified NCT02200419).

Nevertheless, we do believe that additional benefits in coagulation management can be achieved by optimizing heparin management. We have noticed that in some of our patients who bleed unexpectedly, there is a profound deterioration in coagulation status, particularly platelet count and function, from rewarming to postprotamine periods, suggesting a contributory effect of protamine to the coagulopathy.[3] Perhaps, these patients would not have bled if heparin management was optimized by, for example, using mathematical models[4,5] or point-of-care heparin–protamine titration systems.[6]

We therefore agree with Bulatovic and Taneja that systematic studies on heparin management in cardiac surgery are required, as we do not seem to be much ahead of where we were in the 1970s.[7] Perhaps, with optimized heparin

management, we can further improve hemostatic management of cardiac surgical patients and reduce the burden of perioperative coagulopathy.

Competing Interests

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Occupational Hazards of Exposure to Magnetic Resonance Imaging

To the Editor:

The recently published Practice Advisory on Anesthetic Care for Magnetic Resonance Imaging does not comment on the occupational hazards of magnetic resonance imaging (MRI) exposure for anesthesia providers.[1] Transient sensory effects such as vertigo, nausea, dizziness, metallic taste, and visual phosphenes during exposure to MRI have been widely reported in the radiology literature.[2] Vertigo is the most common and potentially most problematic of these symptoms. de Vocht *et al.*[3] surveyed workers in an MRI scanner manufacturing plant, and 22% of the respondents reported experiencing vertigo while at work. In a survey of nurses working in MRI, 7% reported vertigo or dizziness and 12% reported an illusion of movement.[4] Although not a widely recognized phenomenon in the anesthesia community, we recently published a report of MRI-induced vertigo in a nurse anesthetist taking care of a patient in a 3-Tesla scanner.[5]

The exact mechanism of MRI-induced vertigo is unclear, but there may be separate contributions by static and time-varying magnetic fields.[6] Moreover, recent work suggests that the magnetic field induces electrical currents in the endolymph of the vestibular apparatus of the inner ear. This causes deflection of the stereocilia in the hair cells of the cupula, which is then in turn erroneously interpreted by the brain as rotational movement.[7] Regardless of the precise physiology, it is well established that the risk of vertigo increases with the field strength of the MRI scanner, the proximity to the bore of the MRI scanner, and the rate of movement (linear and rotational) within the magnetic field. Because they need to move around inside the MRI room and often attend to patients within the bore of the scanner, anesthesia providers are at significant risk of experiencing vertigo.[3,5,8] Clinical experience suggests that the symptoms are transient and there is no evidence of long-term sequelae. Nonetheless, intense vertigo can be a debilitating experience that may have a profound impact on a practitioner's ability to safely care for a patient in the MRI. Furthermore, there are data to suggest that the exposure to MRI may adversely affect hand–eye coordination and even cognitive performance.[9]

Currently, there are no regulations for occupational exposure to MRI for healthcare workers in the United States. Guidelines published in 2009 (and updated in 2014) by the International Commission on Non-Ionizing Radiation Protection suggest limiting the change in magnetic flux density (magnetic field) to 2 Tesla for any 3-s period, largely because of concerns about vertigo and nausea.[10] Exposure to static magnetic fields of up to 8 Tesla can be justified in controlled environments with appropriate work practices implemented to minimize the motion-related sensory phenomena. These guidelines assume that a clinician in the MRI environment can control his or her distance from the scanner as well as the speed of motion within the MRI room. However, it is easy to imagine an airway emergency occurring within the bore of a 3-Tesla or 7-Tesla MRI scanner, during which there would be little the anesthesia provider could do to limit his or her exposure to a rapidly changing magnetic field.