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

Competing Interests

The authors have received research funding from Tem International GmBH (Munich, Germany) and Helena Laboratories (Beaumont, Texas), for an ongoing multicenter randomized trial of a point-of-care–based coagulation algorithm.

Keyvan Karkouti, M.D., Jeannie Callum, M.D., Vivek Rao, M.D., Ph.D., Stuart A. McCluskey, M.D., Ph.D. Toronto General Hospital, University Health Network, University of Toronto, Toronto, Ontario, Canada (K.K.). keyvan.karkouti@uhn.ca

References

1. Karkouti K, McCluskey SA, Callum J, Freedman J, Selby R, Timoumi T, Roy D, Rao V: Evaluation of a novel transfusion algorithm employing point-of-care coagulation assays in cardiac surgery: A retrospective cohort study with interrupted time-series analysis. Anesthesiology 2015; 122:560–70
2. Ferraris VA, Brown JR, Despotis GJ, Hammon JW, Reece TB, Saha SP, Song HK, Clough ER, Shore-Lesserson LJ, Goodnough LT, Mazer CD, Shander A, Stafford-Smith M, Waters J, Baker RA, Dickinson TA, FitzGerald DJ, Likosky DS, Shann KG: 2011 update to the Society of Thoracic Surgeons and the Society of Cardiovascular Anesthesiologists blood conservation clinical practice guidelines. Ann Thorac Surg 2011; 91:944–82
3. Griffin MJ, Rinder HM, Smith BR, Tracey JB, Kriz NS, Li CK, Rinder CS: The effects of heparin, protamine, and heparin/protamine reversal on platelet function under conditions of arterial shear stress. Anesth Analg 2001; 93:20–7
4. Ödling Davidsson F, Johagen D, Appelblad M, Svenmarker S: Reversal of heparin after cardiac surgery: Protamine titration using a statistical model. J Cardiothorac Vasc Anesth 2015; 29:710–4
5. Suarez CJ, Gayoso DP, Gude SF, Gomez Zincke JM, Rey AH, Fontanillo Fontanillo MM: Method to calculate the protamine dose necessary for reversal of heparin as a function of activated clotting time in patients undergoing cardiac surgery. J Extra Corpor Technol 2013; 45:235–41
6. Runge M, Møller CH, Steinbrüchel DA: Increased accuracy in heparin and protamine administration decreases bleeding: A pilot study. J Extra Corpor Technol 2009; 41:10–4
7. Jaques LB: Protamine—Antagonist to heparin. Can Med Assoc J 1973; 108:1291–7

(Accepted for publication June 15, 2015.)

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.

Downloaded from http://asa2.silverchair.com/anesthesiology/article-pdf/123/4/976/372481/20151000_0-00046.pdf by guest on 17 April 2024

Copyright © 2015, the American Society of Anesthesiologists, Inc. Wolters Kluwer Health, Inc. Unauthorized reproduction of this article is prohibited.

Magnetic resonance imaging–induced vertigo in anesthesia providers may become more common as the strength of MRI scanners increases. We think that education and prevention regarding this problem are imperative. Anesthesia providers should be instructed to stay as far away from the scanner as possible while still providing safe patient care. When possible, clinicians should avoid leaning directly into the bore of the MRI scanner. Rapid movements, including both linear translation and head rotation, should be avoided. Finally, back-up personnel should be available in the event that a provider experiences intense vertigo that impairs his or her ability to safely care for patients. It is our hope that future revisions of the Practice Advisory on Anesthetic Care for Magnetic Resonance Imaging will address these concerns.

Competing Interests

The authors declare no competing interests.

Andrew Gorlin, M.D., Joseph M. Hoxworth, M.D., Jeff Mueller, M.D. Mayo Clinic Arizona, Phoenix, Arizona (A.G.). gorlin.andrew@mayo.edu

References

1. Practice advisory on anesthetic care for magnetic resonance imaging: An updated report by the American Society of Anesthesiologists Task Force on Anesthetic Care for Magnetic Resonance Imaging. Anesthesiology 2015; 122:495–520
2. International Commission on Non-Ionizing Radiation Protection: Guidelines on limits of exposure to static magnetic fields. Health Phys 2009; 96:504–514
3. de Vocht F, van Drooge H, Engels H, Kromhout H: Exposure, health complaints and cognitive performance among employees of an MRI scanners manufacturing department. J Magn Reson Imaging 2006; 23:197–204
4. Wilén J, de Vocht F: Health complaints among nurses working near MRI scanners—A descriptive pilot study. Eur J Radiol 2011; 80:510–3
5. Gorlin A, Hoxworth JM, Pavlicek W, Thunberg CA, Seamans D: Acute vertigo in an anesthesia provider during exposure to a 3T MRI scanner. Med Devices (Auckl) 2015; 8:161–6
6. Glover PM, Cavin I, Qian W, Bowtell R, Gowland PA: Magnetic-field-induced vertigo: A theoretical and experimental investigation. Bioelectromagnetics 2007; 28:349–61
7. Roberts DC, Marcelli V, Gillen JS, Carey JP, Della Santina CC, Zee DS: MRI magnetic field stimulates rotational sensors of the brain. Curr Biol 2011; 21:1635–40
8. de Vocht F, Stevens T, van Wendel-de-Joode B, Engels H, Kromhout H: Acute neurobehavioral effects of exposure to static magnetic fields: Analyses of exposure-response relations. J Magn Reson Imaging 2006; 23:291–7
9. de Vocht F, van-Wendel-de-Joode B, Engels H, Kromhout H: Neurobehavioral effects among subjects exposed to high static and gradient magnetic fields from a 1.5 Tesla magnetic resonance imaging system—A case-crossover pilot study. Magn Reson Med 2003; 50:670–4
10. ICNIRP guidelines for limiting exposure to electric fields induced by movement of the human body in a static magnetic field and by time-varying magnetic fields below 1 Hz. Health Phys 2014; 106:418–25

(Accepted for publication June 22, 2015.)

In Reply:
On behalf of the American Society of Anesthesiologists Task Force on Magnetic Resonance Imaging, we appreciate the efforts of Dr. Gorlin and coauthors to publicize the phenomenon of vertigo and other physical effects that may be experienced by healthcare professionals who work in the magnetic resonance imaging (MRI) environment. They note that these effects are neither widely known nor commonly experienced by anesthesia professionals, even among those who spend a great deal of time providing anesthesia care for patients undergoing MRI. Although there is a lack of strongly supportive evidence, we believe that these experiences may well be related to the strength of the static magnetic field, designated by the tesla number of the scanner, and movement of the individual (or more specifically one's head movement) within that field near its central region. Nurses routinely working with patients lying within 1.5- and more so 3-tesla scanners have reported associated health complaints.[1] Leaning inside the scanner bore to locate the pulse oximeter, find an IV injection port, or assess a patient's airway may be the kind of activity that could produce this sensation. It may be that anesthesiologists do not encounter these effects as much because they are less apt to engage in this activity to the extent as do the nurses with whom we work. Despite the decades-long recognition of MRI-associated vertigo and other neurobehavioral effects, no long-term deleterious consequences have been documented to date.[2]

Awareness of this phenomenon and prudent caution to avoid sudden head movement in the area of the scanner bore would appear to be common sense advice; however, at this time, the accumulated evidence needed for such a recommendation is not available. Admittedly, protocols at some research MRI facilities where 7-tesla and higher static field magnets are in operation prohibit technicians from working alone in the scanner as a precaution against the effects of disabling vertigo and its untoward consequences. At present, we cannot recommend without more compelling evidence that "anesthesia providers be instructed to stay as far away from the scanner as possible" or that "clinicians should avoid leaning directly into the bore of the MRI scanner." Finally, having "back-up personnel available in the event that a provider experiences intense vertigo that impairs his or her ability to safely care for patients" cannot be recommended without evidence that such resources are justified. Although we do agree that this phenomenon may occur more often in the future as higher field strength magnets evolve from the research arena into clinical imaging, the American Society of Anesthesiologists process of practice parameter development will require convincing evidence to make appropriate recommendations regarding neurobehavioral and cognitive effects of MRI. The task force does intend to address this issue in a future update of the Practice Advisory.

Competing Interests

The authors declare no competing interests.

Downloaded from http://asa2.silverchair.com/anesthesiology/article-pdf/123/4/976/372481/20151000_0-00046.pdf by guest on 17 April 2024

Copyright © 2015, the American Society of Anesthesiologists, Inc. Wolters Kluwer Health, Inc. Unauthorized reproduction of this article is prohibited.