Magnesium, Anesthesia, and Hemodynamic Control

Magnesium is commonly used to control hypertension and prevent seizures in preeclampsia, to stop premature labor, to treat cardiac arrhythmias after surgery and myocardial infarction, and to maintain normal circulating concentrations of calcium and magnesium. In addition, magnesium is being investigated to control hypertension from acute cocaine ingestion, to provide brain protection during periods of ischemia, and to prevent changes in spinal cord sensory processing that lead to chronic pain. The physiologic effects of magnesium, which allow for such widespread use, are diverse.

Magnesium has direct cardiac as well as vascular effects. Very high concentrations of circulating magnesium (5-20-fold elevations above normal) directly depress myocardial contractility. A variety of studies using isolated cardiac muscle preparations demonstrate dramatic depression of myocardial contraction by increased magnesium concentrations (6.4-20 mM). This depressant effect may be counterbalanced in vivo by magnesium-induced vasodilation; cardiac output does not decrease (and may even increase) with increased serum magnesium levels (1.5-3.5 mM) in baboons and humans.

The effects of magnesium on vascular tone are multifactorial. Magnesium has direct vascular actions, and thus its effects are not dependent on the sympathetic nervous system. Hypomagnesemia increases, whereas hypermagnesemia decreases vascular tone. One mechanism for the alteration in vascular tone is alteration in smooth muscle calcium permeability, binding, and translocation. By reducing calcium entry in vascular smooth muscle, magnesium may diminish contractility. In addition, magnesium blunts the contractile response of vascular tissue to vasoconstrictors such as norepinephrine and angiotension II. Magnesium has also been shown to inhibit catecholamine release after sympathetic stimulation. All of these actions may be responsible for the effects on blood pressure produced by magnesium administration.

In this issue of ANESTHESIOLOGY, Vincent et al. report their finding that large doses of magnesium (5-6 mg/dl) transiently decreased blood pressure without affecting cardiac output in pregnant ewes. These data are consistent with the reports reviewed above, in which magnesium decreased blood pressure but maintained cardiac output. They also suggest that the cardiovascular changes associated with pregnancy do not qualitatively alter the cardiovascular actions of magnesium. Interestingly, despite decreasing blood pressure, magnesium increased maternal uterine blood flow.

The uteroplacental vasculature is classically believed to be maximally dilated at rest, with blood flow changing passively with changes in perfusion pressure. Actually, selective uterine artery infusion of direct vascular smooth muscle relaxants (e.g., prostacyclin 2 [PGL2]) or relaxants acting via endothelial mechanisms (e.g., bradykinin or acetylcholine) increase uterine blood flow at rest. The current study, employing systemic drug administration, suggests that magnesium has a greater vasodilatory effect on uterine blood vessels (14% decrease in uterine vascular resistance) than on systemic blood vessels (4% decrease in systemic vascular resistance). Differing actions on uterine and systemic vascular beds are not surprising, since some agents (e.g., norepinephrine and phenylephrine) produce greater effects during pregnancy on uterine than on systemic vessels, whereas others (e.g., angiotensin II) produce less.

The group of investigators at the University of Iowa have embarked on a systematic investigation of how local and systemic hemodynamic regulatory mechanisms, relevant to epidural anesthesia in obstetrics, are altered by commonly used obstetric medications (β-adrenergic agonists and magnesium). The current study suggests that magnesium therapy may interfere with maintenance of blood pressure during epidural anesthesia and may se-
lectively increase uterine blood flow. Both observations, if confirmed in clinical trials, carry important clinical implications and raise several questions. For example, we have recently demonstrated in humans that magnesium interferes with the vasoconstrictive but not the inotropic actions of epinephrine. Does this mean that hypotension associated with epidural anesthesia in women receiving magnesium may be resistant to vasopressor therapy? What is the most appropriate vasopressor under such circumstances? This choice depends on the interaction between perfusion pressure and actions of vasopressors and magnesium on systemic and uterine blood vessels.

Magnesium use has expanded from the labor suite into the coronary care unit, and its use in operating room and intensive care settings probably will increase. It behooves us to examine the powerful interactions between this agent and pharmacologic and physiologic mechanisms of hemodynamic control, as exemplified in this investigation in the obstetric setting.

Gary Zaloga, M.D.
Associate Professor
James C. Eisenach, M.D.
Assistant Professor
Department of Anesthesia
Wake Forest University
The Bowman Gray School of Medicine
300 South Hawthorne Road
Winston-Salem, North Carolina 27103

References


