Surgery and the Plastic Brain

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HE medical community and broader society are concerned about the possibility of postoperative cognitive alteration. Many studies have found that postoperative delirium and decrements in cognition lasting months are relatively common. However, studies that have followed patients long-term have generally not found persistent postoperative cognitive decline (POCD) independently attributable to surgery, especially when appropriate nonsurgical control groups have been included.1,2 An important challenge from a research perspective is that POCD does not have consensus diagnostic criteria, and as such is both an elusive and controversial clinical condition. To add to the confusion, recent studies have found that some surgical patients appear to show postoperative cognitive improvement, possibly after resolution of delirium or early POCD.3,4 It is currently unknown whether specific patients may be vulnerable to decline, or even if some patients might experience cognitive improvement (conceivably related to correction of underlying surgical problems or resolution of chronic pain). Whether and to what extent anesthetic techniques, types of surgery, inflammatory responses, postoperative complications, and surgical outcomes contribute to cognitive trajectories remains obscure.5,7

In this issue of Anesthesiology, Kline et al. approach the controversies surrounding persistent POCD employing an innovative approach.5 Using both clinical and neuroimaging data from two cohorts of participants in the Alzheimer’s Disease Neuroimaging Initiative, they investigated whether a surgical cohort (n = 41) had distinct brain morphologic changes and cognitive trajectories compared with a propensity matched nonsurgical cohort (n = 123). This method is intellectually appealing, as quantitative magnetic resonance imaging can accurately track longitudinal changes in brain anatomy. Although volume alteration in various brain regions provides only a surrogate marker of brain health, such alterations in cortical volumes and hippocampal volume loss than the nonsurgical cohort at the first follow-up visit, which for the surgical group was about half a year postoperatively. Those in the surgical cohort who had baseline mild cognitive impairment showed interval POCD at the initial follow-up, using a commonly used definition of POCD based on an arbitrary threshold change in a composite cognitive battery.5 However, even with their rigorous statistical analyses, they appropriately incorporated correction for multiple comparisons, in order to decrease the likelihood of false positive results. However, even with their rigorous statistical methods, there could have been unaccounted for important differences between the surgical and nonsurgical cohorts that might have confounded the results. Furthermore, the surgical group was small and the operations were diverse. It is also important to note that even very healthy elderly people dis-
play longitudinal volume loss in both gray and white brain matter, and subtle cognitive decline occurs with healthy aging. Taking these qualifiers into account, this study should be viewed as generating another hypothesis: after surgery some patients experience temporary, measurable cognitive decline, which is reflected in reversible anatomical changes in specific brain regions. Prospective longitudinal studies, including appropriate surgical and matched nonsurgical cohorts, and incorporating serial neuroimaging and cognitive assessments, would be helpful in testing this hypothesis. Interestingly, these intriguing findings are consistent with recent discoveries and can potentially be explained on biologically plausible grounds.

Surgery is frequently complicated by chronic pain, wound infections, inflammation, and organ dysfunction. Pain, infection, and inflammation carry a cognitive burden, and could possibly exacerbate cognitive decline associated with aging. In several diverse chronic pain states,gray matter brain changes have been observed. Cognitive impairment accompanying dysfunction of other organs, like renal impairment, has become appreciated as common and is recognized as a public health challenge. Neuroimaging studies have suggested that antiinflammatory drugs might in certain circumstances provide protection against age-related loss of brain volume. Patients who receive successful kidney transplants show persistent cognitive improvement. Surgeries that frequently decrease pain and inflammation, such as coronary artery bypass surgery and joint replacement surgery, have been associated with both quality-of-life enhancement and persistent cognitive improvement.

Recent prospective studies that have combined neuroimaging, pain, and functional assessments have shown that when surgery (e.g., back surgery or hip replacement surgery) successfully treats chronic pain (and inflammation), cognition improves and gray matter increases in areas such as the dorsolateral prefrontal cortex, the anterior cingulate cortex, and the amygdala.

What are the implications for perioperative clinicians of the intriguing findings of Kline, Rodriguez-Raecke, and Seminowicz regarding perioperative neuroplasticity? As with other organs, like the heart and kidneys, so too with the brain: acute postoperative dysfunction is probably common and potentially preventable. Conversely, with successful surgery, with resolution of pain and inflammation, and with improvement in quality of life, neuroanatomical changes coupled with improved cognition might occur. The fact that the brain retains a lifelong capacity for plasticity and adaptive reorganization is probably really significant for clinicians caring for elderly people undergoing elective surgery, which predictably and frequently incurs an early cognitive cost, but could also yield sustained cognitive benefit. Importantly, research has shown that dimensions of negative reorganization should be at least partially reversible through the use of an appropriately designed brain-training program. Anesthesiologists should identify patients at risk, attempt to mitigate postoperative delirium and acute neurologic deterioration, and promote successful surgical outcomes with the aim of effecting quality-of-life enhancement coupled with postoperative cognitive improvement. Such an approach would be analogous to our efforts to optimize perioperative cardiorespiratory fitness, which itself improves cognitive function in older healthy people. Specifically, research efforts should be directed toward assessing the potential benefits of perioperative brain-plasticity-based interventions, utilizing cognitive test batteries as well as both functional and structural neuroimaging studies, to determine the efficacy of a brain-training program.

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