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ORIGINAL ARTICLE

Exposure to Surgery and Anesthesia After Concussion Due to Mild Traumatic Brain Injury

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Abstract

Objective: To describe the epidemiology of surgical and anesthetic procedures in patients recently diagnosed as having a concussion due to mild traumatic brain injury.

Patients and Methods: Study patients presented to a tertiary care center after a concussion due to mild traumatic brain injury from July 1, 2005, through June 30, 2015, and underwent a surgical procedure and anesthesia support under the direct or indirect care of a physician anesthesiologist.

Results: During the study period, 1038 patients met all the study inclusion criteria and subsequently received 1820 anesthetics. In this population of anesthetized patients, rates of diagnosed concussions due to sports injuries, falls, and assaults, but not motor vehicle accidents, increased during 2010-2011. Concussions were diagnosed in 965 patients (93%) within 1 week after injury. In the 552 patients who had surgery within 1 week after concussive injury, 29 (5%) had anesthesia and surgical procedures unrelated to their concussion-producing traumatic injury. The highest use of surgery occurred early after injury and most frequently required general anesthesia. Orthopedic and general surgical procedures accounted for 57% of procedures. Nine patients received 29 anesthetics before a concussion diagnosis, and all of these patients had been involved in motor vehicle accidents and received at least 1 anesthetic within 1 week of injury.

Conclusion: Surgical and anesthesia use are common in patients after concussion. Clinicians should have increased awareness for concussion in patients who sustain a trauma and may need to take measures to avoid potentially injury-augmenting cerebral physiology in these patients.

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Concussion is a functional manifestation of mild traumatic brain injury. Although sports-related concussion (and its long-term clinical consequences) has recently received substantial public attention,[1] concussion can also occur after motor vehicle accidents, falls, or assaults. Gross structural changes are often not apparent on nonfunctional brain imaging.[2]

Acute changes in brain physiology can occur after concussion and include alterations in cerebral blood flow (CBF), CBF autoregulation, cerebral metabolism, neurotransmitter release, neurotransmitter receptor expression, blood-brain barrier integrity, and expression of inflammatory cytokines.[3,4] These changes in brain physiology likely account for a constellation of signs and symptoms, including headache, lethargy, memory impairments, sleep disturbances, and psychiatric symptoms, which are referred to as postconcussive syndrome.[5]

Patients involved in trauma and who experience concussion may also experience other injuries (eg, fractures and intra-abdominal injuries) that in aggregate can cause hypotension, hypoxemia, anemia, and hyperglycemia, all of which can potentially augment injury to the brain.[6] These physiologic changes may result endogenously from primary and secondary consequences of trauma, or they may be consequences of surgical and anesthesia interventions (whether the anesthesia is used to facilitate therapeutic or diagnostic procedures).

To date, use of anesthesia and surgery in the immediate, acute, and chronic stages after concussion has not been described. We retrospectively characterized surgical and anesthesia interventions within 1 year in patients who sustained a concussion and sought medical care at a single institution. These data have implications for the planning of

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health care, and the timing of that health care, in patients who have recently experienced a concussion and are presumably vulnerable for secondary brain injury associated with surgical, diagnostic, and anesthetic interventions.

METHODS

All the medical records of patients who received care at Mayo Clinic in Rochester, Minnesota, were screened for those that contained *International Classification of Diseases (ICD)-9* and *ICD-10* codes for concussion (850.X, 854.XX and S06.0X, respectively) from July 1, 2005, through June 30, 2015. Patients in this cohort who had an electronic anesthesia record generated within 1 year after their concussion were identified. The Mayo Clinic Institutional Review Board reviewed and approved the study.

For these patients, all electronic medical records were manually reviewed by 2 anesthesiologists (A.S.A. and J.J.P.). The date of the injury that produced the concussion and the date of concussion diagnosis were both recorded.

Patients with the following characteristics were excluded from the analysis:

(1) Those who did not have a history that was consistent with the Mayo Traumatic Brain Injury Classification System diagnostic criteria for definite, probable, or possible mild traumatic brain injury.[7]
(2) Those with a Glasgow Coma Scale score less than 13 after resuscitation (such that only those with at most mild traumatic brain injury were included in the final data analysis).[8]
(3) Those with a penetrating head injury.
(4) Those with traumatic carotid or vertebral arterial injury. Patients with small intracranial hemorrhages (subdural, epidural, subarachnoid, or intraparenchymal) were included unless the patient was excluded by other criteria.

Duplicate anesthetic records were excluded. Specifically, when multiple anesthetic records were generated during the same anesthetic period due to patient transfer to a different procedural venue, but involving a procedure or diagnostic study in the same medical specialty, we treated that event as a single anesthetic. These events consisted of either multiple procedures performed solely in the radiology suite (eg, magnetic resonance imaging [MRI] with anesthesia and subsequent radiology-guided lumbar puncture) or a lumbar epidural catheter placed for labor with the patient being subsequently transferred to a delivery room for vaginal delivery or cesarean section. Also, a regional block placed in a "block room" by an anesthesiologist with subsequent transfer of the patient to the operating room (OR) for surgery was also treated as a single anesthetic. However, a transfer during the same anesthetic involving a different type of procedure (eg, MRI with anesthesia with subsequent transfer to the OR for an orthopedic surgical procedure) was treated as 2 procedures.

At Mayo Clinic, nonanesthesia providers, such as specially trained registered nurses (ie, sedation nurses), occasionally administer sedation medications and monitor physiologic variables as directed by a physician proceduralist. Sedation nurses administer small doses of the opioid fentanyl and the benzodiazepine midazolam only. These providers use the same electronic anesthesia record to chart physiologic variables and medications as is used by the Department of Anesthesiology and Perioperative Medicine at Mayo Clinic. Any electronic anesthesia records that were generated by nonanesthesia providers, such as sedation nurses, were excluded from the analysis based on knowledge that these patients represent a selection bias for lesser traumatic injury, pharmacologic intervention, and potential to record outcome-influencing physiologic changes. As such, only anesthesia records generated for diagnostic or surgical procedures under the direct or indirect care of a physician anesthesiologist were included in the analysis. Specifically, cases under the direct care of a physician anesthesiologist were those in which a physician (ie, attending, resident, or fellow) was the direct in-room provider. Those under the indirect care of an anesthesiologist were cases in which the in-room provider was either a certified registered nurse anesthetist or a student nurse anesthetist and an anesthesiologist was supervising their care of the patient.

For each patient, demographic characteristics were recorded and the mechanism of injury that resulted in a concussion was classified as a motor vehicle accident, a sports-related event, a

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