Breaking Down Silos to Protect the Spinal Cord

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Not too long ago, we gave an anesthestic to a young man with an incomplete quadraplegia for an internal fixation of an unstable cervical spine (C5-6) fracture. While the choice of the best intubation technique remains controversial, we decided to secure the airway using a flexible bronchoscope with the patient awake. Anesthesia was induced after an uneventful tracheal intubation. The patient was then carefully turned prone, and the patient's head and neck were placed in a markedly flexed position for optimal surgical exposure. After an uneventful procedure, the patient awakened with no new neurological deficits. In light of the conflicting priorities, conventional wisdom, and political issues, it is important for us to reexamine the efficacy of our conventional practices in the protection of the cervical spinal cord during airway management, intraoperative positioning, as well as surgical intervention of the patient with a fractured cervical spine.

During the last two decades, a number of case reports have linked postoperative neurological dysfunction of the cervical spine to tracheal intubation.[1–6] Although some have questioned the validity of these claims,[7,8] most clinicians have avoided cervical spine movement while managing the airway of patients with an unstable cervical spine. Oral intubation under direct laryngoscopy has been deemed dangerous because the excessive cervical spine movement associated with the technique may lead to spinal cord compression, and so worsen the neurological outcome.[9] Protocols and strategies have been developed to protect the cervical spine during airway management, including the use of manual inline immobilization.[10] Unfortunately, manual inline stabilization of the cervical spine has been shown to degrade the laryngoscopic view.[11] Some studies have also questioned the efficacy of the routine use of manual inline stabilization and suggest no benefit in stabilizing injured spinal segments.[12–14] Nevertheless, in the absence of studies with high levels of evidence to establish the safety of tracheal intubation without manual inline stabilization in patients with an injured cervical spine, a strong recommendation against its use cannot be made.[15] Therefore, practitioners should exercise prudence and maintain spinal column immobilization in patients with possible cervical spine injury, albeit allowing judicious movement of the cervical spine if needed to facilitate glottis visualization during direct laryngoscopy.[16]

Recent technological advances have produced a broad spectrum of visualizing and nonvisualizing devices and techniques that do not require alignment of the airway axes, or major movement of the cervical spine during tracheal intubation. Many studies have been conducted to evaluate the clinical utility of these alternative devices and techniques, including the study by Wendling et al.,[17] published in this issue of *Anesthesia & Analgesia*. This study compares relative cervical spine movement during tracheal intubation using 4 airway devices in cadavers with unstable C1-2 ligamentous disruption and the application of manual inline immobilization. Angular movement in 3 axes was assessed using an electromagnetic device during intubation. In this cadaver model, the investigators found that the lightwand technique produced the least movement of the devices being tested. The Airtraq laryngoscope appeared to cause less movement, although not statistically significant, than either the intubating laryngeal mask airway or the Macintosh laryngoscope. A considerable number of similar studies have been conducted over the years, in which cervical spine movement was measured during airway management in both patient and cadaver models with normal or abnormal cervical spines.[18] Interestingly, without exception, all airway interventions, including a chin lift, a jaw thrust, the placement of an oral airway, application of cricoid pressure, placement of a laryngeal mask airway, and performing a surgical cricothyrotomy, cause some cervical spinal movement.[19–23]

While it is reassuring that some airway techniques are associated with less cervical spinal movement than others, and that manual inline immobilization of the spine appears to reduce the likelihood of spinal movement during airway interventions, the clinical significance of this movement remains largely unknown. White and Panjabi[24] suggested that the upper limit of physiologic angular displacement of a vertebral body compared with adjacent vertebrae was 11°, and any spinal movement exceeding this threshold should be deemed unstable at the site of the excessively rotated vertebra. With respect to horizontal displacement, the spine is considered at risk if the horizontal displacement exceeds 3.5 mm (corrected for x-ray magnification), or 20% of the vertebral body width on lateral radiographs of the neck (or with flexion–extension views or dynamic

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fluoroscopy). However, the relationship between these cervical spine movements and subsequent neurological deterioration of the spinal cord has not been determined. There are no randomized controlled clinical trials to support the notion that a reduction in neck movement by a certain degree protects against neurological deterioration caused by intubation. Given the rarity of the postintubation neurological deterioration, such a trial would require a large sample size to have sufficient power and would present formidable logistical and ethical obstacles. It is not surprising that several reviews consistently concluded that it is not possible to establish tracheal intubation as the definite cause of any deterioration in neurological outcomes in this patient population.[18,25,26]

Modern trauma and emergency care systems, along with improvements in surgical and pharmacological management, have been developed to improve outcomes in patients with acute cervical spinal cord injury. Although these strategies may lead to an improved outcome, secondary neurological deterioration does occur in a small number of patients (5%–6%).[1,27] There is a growing body of evidence to suggest that the outcome of this patient population depends on a complex interaction between primary and secondary injury mechanisms after the initial spinal cord insult. The deterioration following the initial injury may result from a combination of hypoperfusion and ischemia, inflammatory responses, as well as biochemical, molecular, and cellular changes.[1,27] Would a short-lived cervical spine movement during airway intervention increase the likelihood of secondary neurological deterioration? Probably not, but the possibility is difficult to ignore.[8] With no clinical outcome data, it is not possible to draw a valid conclusion using surrogate measures, such as cervical spine movement. Instead of speculating about the acceptable limits of cervical spine movement, the best airway technique, or optimal surgical positioning, it would be better to use an effective measurement of the outcome of the spinal cord injury. Although it may not be easy to measure the outcome of a complex and often unpredictable spinal cord injury, neuronal injury has been shown to illicit a number of electrophysiological changes.[28] In an attempt to continuously monitor the functionality of the spinal cord during spinal procedures, neurophysiologists have been using the signals of somatosensory evoked potentials (SSEPs), and transcranial electrical motor-evoked potentials (TcMEPs) for many years. Recent large retrospective clinical reviews have supported the ability of TcMEP and SSEP to detect impending iatrogenic neural injury during cervical spine and scoliosis surgeries.[29,30] The TcMEP appears to be a better method of detecting evolving motor tract injury during cervical spine surgery when compared with conventional SSEP.[31] Although a systematic review of the utility of electrophysiological monitoring questioned its reliability in forecasting outcome,[32] the results from a large recent retrospective study involving 12,375 monitored spine cases provide further support of the utility of intraoperative neurophysiological monitoring in the prediction and prevention of iatrogenic spinal cord injury.[33] Unfortunately, there are limitations in using the TcMEP and SSEP to monitor spinal cord function during tracheal intubation, because anesthesia, movement, and muscle paralysis affect the interpretation of these electrophysiological signals. Perhaps multimodal neurophysiological recordings,[34] including the use of neurogenic evoked potentials,[35] should be considered.

How should we proceed if neurophysiological monitoring is unavailable to us? The simplest approach might be to secure the airway of these patients awake and position them prone to ensure intact neurological function before inducing general anesthesia with muscle relaxation. Unfortunately, there is also no guarantee that even this cautious approach would prevent neurological deterioration, since Deem et al.[36] have reported that postsurgical quadriplegia could occur even though tracheal intubation and prone positioning took place while the patient was awake. Furthermore, some patients may not tolerate awake intubation. Neurological deterioration following the initial cervical spine injury depends on many factors. If we strive to avoid neurological deterioration during airway intervention, we cannot succeed in isolation. As indicated in the Guidelines for the Management of Acute Cervical Spine and Spinal Cord Injuries of the American Association of Neurological Surgeons,[37] the "best practice" strategies for these patients must include all aspects of the care of acute cervical injury: expeditious and skilled prehospital care and transport, neurological and radiographic assessment, medical management of spinal cord injury, closed reduction of cervical fracture-dislocations, and specific treatment options (both operative and nonoperative) for each specific cervical injury type known to occur, from the occiput through thoracic level 1. In other words, while it is difficult to find any strong evidence to favor one strategy over the other in managing the airway of patients with an unstable cervical spine, we should strive to provide excellence in each aspect of the perioperative care of these patients. Airway management of these patients should include careful immobilization of the neck, with minimal spine movement, while using one of the airway alternatives at our disposal. Meticulous attention should be paid when positioning the patient under anesthesia with the goal of maintaining optimal oxygenation and perfusion of the spinal cord and to minimize edema throughout the perioperative period. The use of multimodal intraoperative neuromonitoring is desirable because it allows clinicians to continuously monitor the state of the spinal cord throughout the perioperative period. In addition, postoperative aggressive rehabilitation should be used and spinal cord deterioration should be identified early, and managed with optimal pharmacotherapy. Although the investigation of neurotrophic support of nerve regeneration is just beginning, results of this research may lead to its playing an important role in the recovery of patients with a traumatic cervical spinal cord injury in the near future.[38]

It is clear that the prevention of neurologic complications following airway and surgical interventions in patients with cervical spinal cord injury requires a multidisciplinary team approach. While the application of manual inline immobilization of the neck and the use of an airway technique that is associated with minimal cervical movement are necessary steps to ensure a favorable outcome for patients undergoing a spinal stabilization procedure, it is vital to engage emergency physicians,

neurosurgeons, anesthesiologists, radiologists, neurologists, neurophysiologists, and intensivists in developing scientifically sound strategies to ensure the best outcome possible in these patients.

In the case of our patient and in retrospect, after carefully securing the airway of our patient in the operating room, it may have been better to collaborate with the neurosurgeon and a neurophysiologist in properly positioning the neck of the patient, and in monitoring the spinal cord function throughout the surgical procedure as well as in the postoperative period. Our role then could focus on the detection, monitoring, and subsequent management of any postoperative deterioration of spinal cord function. Breaking out of our specialty silos to work as a collaborative team could do much to improve the outcome of patients with spinal cord injury.

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