Craniovertebral junction trauma

Traumatic injury of the craniovertebral junction (CVJ) area is common and frequently influence the outcome of motor vehicle accidents, falls, and diving accidents.

Fatal craniovertebral junction (CVJ) injuries were the most common cause of death in high-speed motor sports prior to 2001. Following the death of a mutual friend and race car driver, Patrick Jacquemart (1946-1981), biomechanical engineer Dr. Robert Hubbard, along with race car driver and brother-in-law Jim Downing, developed the concept for the Head and Neck Support (HANS) device to prevent flexion-distraction injuries during high-velocity impact. Biomechanical testing showed that neck shear and loading forces experienced during collisions were 3 times the required amount for a catastrophic injury. Crash sled testing with and without the HANS device elucidated reductions in neck tension, neck compression, head acceleration, and chest acceleration experienced by dummies during high-energy crashes. Simultaneously, motor sports accidents such as Dale Earnhardt Sr.'s fatal crash in 2001 galvanized public opinion in favor of serious safety reform. Analysis of Earnhardt's accident demonstrated that his car's velocity parallel to the barrier was more than 150 miles per hour (mph), with deceleration upon impact of roughly 43 mph in a total of 0.08 seconds. After careful review, several major racing series such as the National Association for Stock Car Auto Racing (NASCAR) and Championship Auto Racing Team (CART) made major changes to ensure the safety of drivers at the turn of the 21st century. Since the rule requiring the HANS device in professional auto racing series was put in place, there has not been a single reported case of a fatal CVJ injury [1].

Epidemiology

Although the exact proportion of cervical spine fractures that involve this region is not known, sources estimate that a third to half of all cervical spine injuries involve the CVJ [2] [3] [4].

Classification of trauma

To define and characterize CVJ traumatic injuries, some international classifications are currently in use, and they are thought and focused on junction bone fracture. However, recent data point out a major important role of the CVJ ligaments and membranes in traumatic injuries with a secondary function of the osseous structures. Emphasizing the correct role of the ligaments and membranes is extremely important for determining appropriate medical or surgical planning for patients and also to design new CVJ injury classifications.

Debernardi et al. reviewed every recent major publication on the ligaments and membranes of the CVJ area and divided the information into sections concerning anatomy, embryology, biomechanics, trauma, and CVJ bone fractures. A role of the ligaments and membranes in the traumatic injuries of the CVJ area has often been recognized; but only recently, with the increase in the knowledge of the anatomic and biomechanical junction area, supported by neuroradiological tools (magnetic resonance imaging) and a more detailed traumatic injuries assessment, has the role of the ligaments and membranes been highlighted. Ligaments and membranes have a pivotal role in each junctional ability and are the key to orienting any medical or surgical indications in this unique area of the spine [5].

Diagnosis

Many patients with CVJ trauma have an altered level of consciousness or other injuries that can make the physical examination difficult or less reliable. This can lead to delayed or missed diagnosis of CVJ injuries. Conventional radiographs or CT scans can reveal bony anatomy with great detail and have a high sensitivity for fractures. However, many bony injuries of the CVJ are not inherently biomechanically unstable and therefore do not require surgical intervention. Conversely, patients with unstable CVJ injuries requiring surgery may not necessarily have fractures. Therefore, determining the integrity of ligamentous structures of the CVJ is paramount in deciding whether surgical stabilization is necessary [6].

Ligamentous injury is often the indication for surgical stabilization of the CVJ. Changes associated with CVJ ligamentous injuries may be subtle on CT imaging, and there should be a low threshold for the use of MRI in cases of suspected cervical spine injury in patients with high-energy mechanisms of injury. Neurosurgeons must be able to recognize the CT and MRI characteristics of CVJ instability to determine when surgical treatment is warranted. Most recommendations for the management of patients with verified or suspected cervical spine or CVJ injuries comes from Class 3 evidence, and the use of MRI in evaluation of these patients is largely based on clinical judgment. The increasing availability of MRI will likely lead to a lower threshold for its use, and guidelines should be established to help limit missed injuries as well as the expense of unnecessary imaging [7].

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