Axis fracture

Epidemiology

The C2 or axis fracture accounts for nearly 19% of all spinal fractures and 55% of cervical fractures. Within C2 fractures, the hangman's fracture accounts for 23% of occurrences while the odontoid or dens fracture accounts for 55% of them.

C2 dominated the single level injury and most of them were type II odontoid fractures \(^1\).

Types

Odontoid fracture.

Hangman's fracture.

Axis vertebral fracture.

Although not as common as Type II odontoid fractures, other C-2 fractures including hangman's, complex, and Type III odontoid fractures accounted for close to half of the injuries. There are few differences between the fracture types with respect to cause of injury, predisposing factors, or mortality rate. However, surgical treatment was more common for Type II odontoid fractures \(^2\).

Management

If axis fracture involves the adjacent segment instability and even dislocation, it can easily lead to high cervical spinal cord injury and vertebro-basilar artery insufficiency, thus resulting in quadriplegia and even life-threatening condition. The principle for the surgery is that axis fracture type should be considered and the adjacent instable segments should be fixed to restore the stability between C1/2/3. Personalized surgical method should be selected for each patient, thus achieving a effective fixation and preserve the movement phase of the spine as much as possible \(^3\).

Management of axis fractures in the elderly remains controversial.

Outcome

Knowledge on the outcome of C2-fractures is founded on heterogenous samples with cross-sectional outcome assessment focusing on union rates, complications and technical concerns related to surgical treatment. Reproducible clinical and functional outcome assessments are scant. Validated generic and disease specific outcome measures were rarely applied \(^4\).

Complications

The vertebral arteries are susceptible to injury as each courses through the C2 transverse foramen. Early screening for vertebral artery injury to institute antithrombotic treatment is critical to prevent ischemic neurologic sequelae. Imaging-based fracture classification schemes to determine which patterns are predictors of VAI in isolated C2 fractures using CTA have not been described.

Cervical-spine CTs at a level I trauma center were reviewed for isolated C2 fractures from 2004-2014 under institutional board review approval. Exclusion criteria included penetrating injury or additional
cervical/occipital fractures. Fractures were classified using multiplanar CT images into Type-I/II/IIa/III spondylolisthesis, Type-I/IIA/IIB/IIC/III dens, transverse foramen (displacement/comminution/intraforaminal fragments), and miscellaneous vertebral body fractures. Corresponding CTAs were assessed for vertebral artery injury based on the Denver grading criteria. Fisher exact and student-t tests were performed to determine predictors of VAI based on fracture type.

Sixty-seven patients met inclusion criteria. Fracture pattern analysis revealed that the majority were dens fractures (50.8%) and traumatic spondylolisthesis (41.8%). 29.9% had miscellaneous coronal/sagittal fractures and 22.4% were a combination. Vertebral artery injury was identified in 37.3% patients with isolated C2 fractures, and 88% had transverse foramen involvement. Fracture patterns significantly associated with VAI were Type III dens and transverse foramen fractures with intraforaminal fragments, with or without comminution.

The C2 fracture pattern most associated with VAI was comminuted transverse foramen fracture with intraforaminal fragments. Transverse foramen fracture alone was not found to be significant. These results help to stratify patients with isolated C2 fractures that are at high VAI risk and should be further evaluated with CTA.

**Case series**

2017

A retrospective cohort study design was used. Patients who sustained an axis fracture between 2002 and 2011 and who were admitted to the authors' Level 1 trauma center were identified using the Discharge Abstract Database and the International Statistical Classification of Diseases and Related Health Problems (ICD-10) code S12.1. Fractures were classified as odontoid Type I, II, or III; hangman's; C-2 complex (hangman's appearance on sagittal images, Type III odontoid on coronal cuts); and other (miscellaneous). Age, sex, predisposing factors to falls, cause of injury, treatment, presence of autofusion in the subaxial cervical spine, and mortality rates were compared between fracture patterns.

One hundred forty-one patients were included; their mean age was 82 years. Fractures included Type II odontoid (57%), complex (19%), Type III odontoid (11%), hangman's (8%), and other (5%). Falls from a standing height accounted for 47% of injuries, and 65% of patients had ≥ 3 risk factors for falls. Subaxial autofusion was more common in odontoid fractures (p = 0.002). Treatment was mainly nonoperative (p < 0.0001). The 1-year mortality rate was 27%. Four patients died of spinal cord injury.

Although not as common as Type II odontoid fractures, other C-2 fractures including hangman's, complex, and Type III odontoid fractures accounted for close to half of the injuries in the study cohort. There were few differences between the fracture types with respect to cause of injury, predisposing factors, or mortality rate. However, surgical treatment was more common for Type II odontoid fractures.

In a retrospective cohort study of 3847 patients age ≥ 80 years representing 17702 incidents nationwide, divided into surgery/nonsurgery cohorts, using the National Sample Program of the National Trauma Data Bank from 2003 to 2012. Inpatient complications, mortality, length of stay, and discharge disposition are characterized; multivariable regression was utilized to determine associations between surgery and outcomes. Institutional Review Board (IRB):
The National Sample Program dataset from the National Trauma Data Bank is fully deidentified and does not contain Health Insurance Portability and Accountability Act identifiers; therefore, this study is exempt from IRB review at the University of California, San Francisco.

Incidence of surgery was 10.3%. Surgery was associated with increased pneumonia, acute respiratory distress syndrome, and decubitus ulcer risks (P < .001). Inpatient mortality was 12.8% (nonsurgery-13.0%; surgery-10.3%; P = .120). Length of stay was 8.31 ± 9.32 days (nonsurgery 7.78 ± 9.21; surgery 12.86 ± 9.07; P < .001) and showed an adjusted mean increase of 5.68 days with surgery (95% confidence interval [4.74-6.61]). Of patients surviving to discharge, 26% returned home (nonsurgery-26.8%; surgery-18.8%; P = .001); surgery patients were less likely to return home (odds ratio 0.59 [0.44-0.78]).

The present study confirms that surgery of traumatic C2 fractures in octogenarians does not significantly affect inpatient mortality and increases discharge to institutionalized care. Patients undergoing surgery are more likely to require longer hospitalization and suffer increased medical complications during their stay. Given the retrospective nature of this study, it is unclear whether these conclusions reflect differences in injury severity between surgery cohorts. This question may be considered in a future prospective study.

2016

From 2003 to 2012, 3847 people met inclusion criteria, which represents 17702 incidents nationally. The overall incidence of operative management was 10.3%. Operative management was associated with increased risk of pneumonia (10.1% vs 5.9%, P < .001), acute respiratory distress syndrome (6.0% vs 2.3%, P < .001), and decubitus ulcer (4.8% vs 1.3%, P < .001). Inpatient mortality was 12.8% for all subjects and was not significantly different between nonoperative and operative cohorts (nonoperative 13%; operative 10.3%; P = .120). Overall hospital LOS was 8.31 ± 9.32 days (nonoperative 7.78 ± 9.21; operative 12.86 ± 9.07; P < .001) and showed an adjusted mean increase of 5.68 days with operative management (95% confidence interval [CI], 4.74-6.61). Of patients who survived to discharge, 26% returned home (nonoperative 26.8%; operative: 18.8%; P = .001). Patients who underwent operative management were less likely to return home (odds ratio, 0.59; 95% CI, 0.44-0.78).

The present study confirms that operative management of traumatic C2 fractures in octogenarians does not significantly affect inpatient mortality and increases the rate of discharge to institutionalized care. Patients undergoing surgery are more likely to require longer hospitalization and experience higher rates of medical complications during their stay.

A total of 30,472 adult patients with C2 fractures (International Classification of Diseases, Ninth Revision, Clinical Modification code 805.02) registered in the Nationwide Inpatient Sample (NIS) database (2002-2011) comprised the patient sample.

Inpatient mortality, unfavorable discharge, prolonged length of stay (LOS) and high-end hospital charges in the non-operative and operative cohorts, and postoperative complications (deep venous thrombosis [DVT]; acute renal failure [ARF]; respiratory complications and wound infections) for the operative cohort were the outcome measures.

Patients were stratified into four categories based on injury type: (1) isolated C2 fracture (n=10,135; 33.3%); (2) C2 fracture+OSI (8.7%); (3) C2 fracture+ESI (37.2%); and (4) C2 fracture+OSI+ESI (20.8%). Multivariable logistic regression fitted with generalized estimating equations using the
sandwich variance-covariance matrix estimator to account for clustering of similar outcomes within hospitals was used to examine the association of primary endpoints for each of the associated injury categories with reference to isolated C2 fractures.

Mean age of the cohort was 66.27±21.67 years and 52% were female. Of the cohort, 52% underwent surgical intervention for C2 fracture. In a pooled regression analysis involving the operative cohort, the risks for inpatient mortality (odds ratio [OR]: 3.77; 95% confidence interval [CI]: 3.02-4.70; p<.001), unfavorable discharge (OR: 1.83; 95% CI: 1.66-2.01; p<.001), prolonged LOS (OR: 1.33; 95% CI: 1.18-1.50; p<.001), high hospital charges (OR: 1.49; 95% CI: 1.31-2.69; p<.001), DVT (OR: 2.08; 95% CI: 1.61-2.68; p<.001), and ARF (OR: 1.46; 95% CI: 1.16-1.83; p=.001) were significantly higher in patients with additional injuries when compared with patients with C2 fractures alone. Likewise, increased chances of inpatient mortality (OR: 1.40; 95% CI: 1.21-1.62; p<.001), unfavorable discharge (OR: 1.24; 95% CI: 1.15-1.34; p<.001) and high hospital charges (OR: 1.31; 95% CI: 1.21-1.43; p<.001) were observed in a pooled analysis of patients with concomitant associated injuries in the non-operative cohort.

Associated injuries occurring concomitantly with C2 fractures adversely influence postoperative outcomes. In comparison to isolated C2 fractures, patients with associated injuries tend to have a greater propensity for higher health-care resource use because of more complicated and longer hospital inpatient stay.


