Examining the Sensitivity of Bedside Diagnosis of Ipsilateral Retrobulbar Hemorrhage in Cases of Acute Orbital Fracture

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Purpose: To investigate the ability to clinically diagnose ipsilateral retrobulbar hemorrhage in the setting of acute orbital fracture (AOF) by using computed tomography (CT) as a gold standard in comparison to bedside physical examination techniques.

Methods: We conducted a retrospective review of 306 consecutive cases of acute orbital fracture that presented to Bellevue Hospital from July 2007 to May 2010. Of these, 28 cases of concurrent retrobulbar hemorrhage as evidenced on CT were noted and set aside for subgroup analysis. Medical records were screened for demographic features, associated history, ocular/systemic co-morbidities, and radiographic findings. An IRB exemption was obtained from the Bellevue Research Committee.

Results: Mean age in the study cohort was 48.4 years (Range: 27 - 90) with equal distribution of males and females. Via radiographic review, 21.4% of patients had fractures of only the orbital floor while 7.1% of patients had only either a fracture of the orbital roof, medial wall, or lateral wall, respectively; the remaining 16 patients had fractures of multiple orbital walls. Mean intracocular pressure (IOP) by tonopen in our patients was 21.6 mmHg (Range: 11 - 51). By using CT imaging as the gold standard for the diagnosis of retrobulbar hemorrhage in comparison to clinical signs that may indicate the finding, we were able to retrospectively calculate the sensitivity, specificity, positive predictive value (PPV), and positive likelihood ratio (LR+) for bedside accurate diagnosis utilizing asymmetric exophthalmometry, increased IOP, and/or a combination of the two. Asymmetric exophthalmometry had a 37.5% sensitivity, 92.4% specificity, 21.4% PPV, and 4.9% LR+, while IOP>30 had a 16.7% sensitivity, 91.9% specificity, 21.4% PPV, and 2.1% LR+. When combined, bedside Hertel’s measurements and IOP>30 had 40% sensitivity, 91.8% specificity, 21.4% PPV, and 4.9% LR+ in predicting retrobulbar hemorrhage that was later confirmed on CT.

Conclusions: Acute orbital fracture with concurrent retrobulbar hemorrhage requires immediate attention to prevent visual compromise. In our study, fractures of multiple orbital walls correlated most with the presence of retrobulbar hemorrhage, rather than fracture of a single wall. Although well-described, the diagnosis of retrobulbar hemorrhage in the setting of AOOF cannot always be made on elevated IOP and/or orbital asymmetry, alone. While these examination techniques may raise suspicion for retrobulbar hemorrhage, CT remains the gold standard for detection and definitive treatment.

Commercial Relationships: Samuel Baharestani, None; Julia Nemiroff, None; Caroline Rosenberg, None; Boaz Lissauer, None

Support: None

Biomechanical Modeling of Eye Trauma for Different Orbit Anthropometries

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Purpose: Over 1.9 million eye injuries occur annually in the U.S., resulting in 30,000 cases of blindness. In military, automotive, and sporting safety, there is concern over eye protection and the effects of facial anthropometry differences on risk of eye injury. This study’s objective was to model differing orbital anthropometries to study the biomechanical response of the eye when subjected to a blunt impact.

Methods: Measurements of the orbital aperture, brow protrusion angle, eye protrusion, and the eye location within the orbit were used to model 27 different orbit anthropometries. Impacts were modeled using an eye model incorporating lagrangian-eulerian fluid flow for the eye, representing a full eye for evaluation of omnidirectional impact and interaction with the orbit. Computational simulations of a Little League (CD25) baseball impact at 30.1 m/s were conducted to assess the effect of orbit anthropometry on eye injury metrics. Parameters measured included stress and strain in the corneoscleral shell, internal dynamic eye pressure, and contact forces between the orbit, eye, and baseball.

Results: Peak stresses ranged from 11-24 MPa and peak pressure ranged from 0.6-2.4 MPa. Eye response varied significantly with anthropometry. Main effects and interaction effects identified in a statistical analysis illustrate the complex relationship between the anthropometric variation and eye response.

Conclusions: Results suggest the eye is more protected from impact with smaller orbital apertures (p=0.038), more brow protrusion (p=0.014), and less eye protrusion (p=0.002), provided that the orbital aperture is large enough to derton contact of the eye with the orbit. Results of this study are relevant to the design and regulation of motor vehicle safety systems and eye protection equipment for sports and military applications.
The purpose of the current study was to computationally model experimental eye trauma from a wide variety of projectile impacts and loading scenarios with common sources. Simulations employed, and postoperative visual and anatomic outcomes at 6 months and final follow-up were evaluated.

Results: Nearly 10% of all casualties sustained ocular injury; nearly half of those patients have been treated at the Walter Reed Army Medical Center. Fortunately, the majority of patients retained excellent vision, yet devastating ocular injuries still occur. Improved tracking and longer followup is essential to measure long-term effects of these injuries and improve outcomes for patients.
impact tests in the literature to analyze global and localized responses of the eye to a variety of blunt projectile impacts.

**Methods:** Simulations of 79 experimental tests were run with 8 different projectiles (airsoft pellet, baseball, BB, blunt impactor, paintball, aluminum, foam, and plastic rods) to characterize effects of the projectile size, mass, shape, material, and velocity on eye response. This study presents a matched comparison of experimental test results and computational model outputs including stress, energy, and pressure used to evaluate risk of globe rupture.

**Results:** Globe rupture was predicted with stresses exceeding 17 MPa and internal pressures exceeding 1.0 MPa in the simulations. The computational results agreed strongly with the experimental results with a specificity of 0.92 and a sensitivity of 1. Peak stresses were located at the center of the cornea, the limbus, or the equator depending on the projectile type. Area-normalized kinetic energy was the single best projectile predictor of peak stress and pressure. Additional incorporation of a relative size parameter relating the projectile area to the eye area reduced stress and pressure predictions depending on the projectile type. Area-normalized kinetic energy was the single best projectile predictor of peak stress and pressure. Additional incorporation of a relative size parameter relating the projectile area to the eye area reduced stress and pressure predictions depending on the projectile type. Area-normalized kinetic energy was the single best projectile predictor of peak stress and pressure.

**Conclusions:** Stress and pressure response of the eye was determined through computational modeling of a variety of projectiles and loading conditions.
Program Number: 5587 Poster Board Number: A425
Presentation Time: 8:30 AM - 10:15 AM

Indications For CT Scan In Patients with Trauma

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Purpose: A computed tomography scan (CT) is the current gold standard for the diagnosis of orbital fractures. Given the recent heightened awareness of radiation exposure associated with CT imaging, we reviewed the yield of orbital CT scans in patients with orbital trauma presenting to a tertiary care eye center.

Methods: Retrospective case series. All consecutive orbital CT scans between 2008 and 2010 that were performed after orbital trauma were reviewed. Demographics, patient symptoms, and physical exam findings were noted.

Results: The charts of 107 patients with CT scans for orbit trauma were reviewed. 50 patients (47%) had radiographic evidence of a fracture (average age 30±13.8 yrs, 88% male, 48% Caucasian, 20% Hispanic). 57 patients (53%) had no fracture on CT scan (average age 43±20.7 yrs, 61% males, 54% Caucasian, 23% Hispanic). The following signs and symptoms were associated with fracture: 88% with complaints of binocular diplopia, 39% of patients without diplopia had a fracture (p<0.001), 92% of patients with extraocular motility restrictions in any gaze, 32% of patients with full motility (p<0.001), 73% with commotio retinae, 42% of those without commotio retinae (p=0.05), 73% of those patients with peri-orbital hypoesthesia, 44% of those without complaints of hypoesthesia (p=0.06), 50% of those patients with 2 mm or greater difference in Hertel exophthalmometry between affected and unaffected eyes, 46% of those less than or equal to 2mm difference. Of the 50 patients with fractures, three patients required surgical repair.

Conclusions: We have established that in patients with commotio retinae, binocular diplopia, and restriction of extraocular movements, performing an orbital CT scan after trauma is likely to reveal radiographic evidence of an orbital fracture. This imaging is required for surgical planning. Only three of the 107 patients who underwent a CT scan underwent surgical repair, perhaps refining clinical features that are associated with a fracture could change the current practice pattern of using a CT scan for all orbital trauma patients. These results will form the basis of a prospective trial comparing the utility of an orbit CT scan to a facial X-ray, which poses a lower radiation risk, as a screening image for trauma.