A COMPREHENSIVE APPROACH TO STUDYING MILD TRAUMATIC BRAIN INJURIES IN MOTOR VEHICLE CRASHES

Zhifeng Kou, Mariusz Ziejewski
North Dakota State University
email: zhifeng.kou@ndsu.edu

INTRODUCTION

Mild traumatic brain injury (MTBI) has the incidence rate of 1.2 million people in the United States, and most of whom are caused in motor vehicle crashes (MVC) [1]. However, the biomechanics of MTBI is not well understood. Biomechanical study of the injury mechanisms of MTBI is difficult due to the non-applicability of the various surrogates including animals, volunteers, and cadavers that were traditionally used in impact biomechanical studies. This study was to determine a method used in a comprehensive study of MTBI involved in MVCs.

METHODS

Our biomechanical approach consists of several steps and all of them are well-accepted methods: 1.) Crash investigation of MVCs on scene. In this step, we could determine the Delta V (the maximum change in velocity at the time of collision) by using Crash3 program [2,3], the angle and type of impact. 2.) Computer modeling of vehicle occupant. We used the Articulated Total Body (ATB) computer software to analyze the human body dynamics [4]. The vehicular acceleration time histories employed in the ATB simulations were based on the analyses performed using well-accepted methods in the engineering community that include vehicle-specific bumper rating strength, extent and nature of structural damage to vehicle, etc. The data set of occupant body including the segments' geometric and mass properties are computed using the Generator of Body Data (GEBOD) computer program [5]. 3.) Assessment of the state-of-the-art biomechanical predictors of brain injury. Based on the body kinematics data, we developed a computer program to calculate the results of the following, but not limited to, models published in the literature: a) resultant maximum linear and angular accelerations, the Head Injury Criteria (HIC), the Generalized Model for Brain Injury Threshold (GAMBIT), the Head Impact Power (HIP), and the Power Index (PI). 4.) Correlation of the biomechanical prediction with medical results. All of the patients in our study had complete medical record. If a patient is identified as MTBI by either clinical neurological diagnosis and/or neuropsychological assessment using the definition by American Congress of Rehabilitation Medicine [6], this patient case was called an affirmative MTBI case. We considered the occurrence of MTBI as a dependent variable and the parameters of each biomechanical model as an independent variable. By using logistic regression analysis, we could determine the power and statistical significance of each biomechanical predictor in predicting MTBI and the contribution of each biomechanical predictor in the injury mechanisms of MTBI.

RESULTS AND DISCUSSION

In our ongoing effort of biomechanical reconstruction of motor vehicle accidents, we collected the consent of 20 (n=20) patient cases with complete crash data and medical records. Of these patients, 8 (40%) (n1=8) of them are affirmative MTBI patients and 12 (60%) (n2=12) of them are non-MTBI patients used as control group. Two groups have the similar patterns in their gender and age distributions (Table 1).

Table 1: Patients' demographic data

MTBI		Gender Distribution	Age Distribution			
			Age	#	Age	#
Yes	n1=8	female = 8 male = 4	21-30	3	31-40	3
			41-50	4	>50	2
No	n2=12	Female = 6 Male = 2	21-30	0	31-40	2
			41-50	5	>50	1

The logistical regression results show that all of the biomechanical parameters are statistically significant in predicting MTBI; however, their predicting power are different and categorized from high to low in terms of -2log likelihood ratio shown in Table 2 from left to right.

CONCLUSIONS

Our comprehensive method proved to be effective and practical in studying of MTBI.

REFERENCES

1. Jager T, et al. "Traumatic brain injuries evaluated in US emergency departments, 1992-1994." *Acad Emerg Med.* 2000;**7**:134-140.
2. Ricci L. "NCSS Statistics: Light Trucks and Vans," *NTIS Report DOT-HS-805-531*, 1980a.
3. Ricci L. "NCSS Statistics: Passenger Cars," *NTIS Report DOT-HS-805-531*, 1980b.
4. Cheng H, Rizer AL. *Articulated Total Body Model Version V User's Manual*. United States Air Force Research Laboratory, 1998.
5. Cheng H, et al. "Generator of Body Data (GEBOD) Manual," *Armstrong Laboratory Report, AL-CF-TR-1994-0051*, 1994.
6. American Congress of Rehabilitation Medicine (ACRM). "Definition of Mild Traumatic Brain Injury." *J. of Head Trauma Rehabilitation*, **8**:86-87, 1993.

Table 2: Significance of Biomechanical Predictors (higher is more significant)

Biomechanical Predictor	**Ang Acc (*100r/s*s)**	**Gambit**	**PI**	**HIP**	**Delta V**	**HIC15**	**Linear Peak G**	**HIC36**
-2log likelihood Ratio	47	39	32	29	24	23	22	21