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Motor Vehicle Collision

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Introduction

According to the Centers for Disease Control and Prevention (CDC), motor vehicle collisions (MVC) in 2013 accounted for over 2 million injuries and more than 32,000 deaths annually in the United States (US) [CDC, 2016]. The National Spinal Cord Injury Statistical Center cited the most common cause of spinal cord injuries (SCI) in the US between the years of 2010 and 2013 was MVCs, accounting for 38% of these injuries. [Mukherjee, Beck, Yoganandan & Rao, 2015].

Mechanism of Injury

Mechanism of injury (MOI) specifically refers to the method by which trauma and its associated forces directly or indirectly impacts the human body. MOI implies a specific transfer of energy from one source (i.e. the environment) to another (i.e. the human body).

These injury patterns assist in the determination of the extent of an injury and fundamental decision-making process regarding trauma triage guidelines.

Energy transfer from the environment can result from a variety of causes. The intensity of the energy transfer will cause damage to the surrounding tissues, organs, muscles, and other body structures when it exceeds the body's ability to resist such rapid, forceful energy changes.

According to the Law of Conservation of Energy, "Energy can neither be destroyed or created, but it can change form." This law goes to the essence of trauma. The kinetic or moving energy must be transferred onto the object impacted. So, if a vehicle is traveling at a high rate of speed when it impacts an object, the energy force can be quadrupled. Spinal injuries may be a result of axial loads (Kaufman, Ching, Willis, Mack, Gross & Bulger, 2013).

Function

Terminology

- Kinematics: the *actual* or *potential* injuries realized by the human body
- Biomechanics: refers to the actual force or impact imparted on the soft tissues and the body
- Mechanism of Injury: the exact cause of the injury and the implied transference of energy from one body to another (i.e. from the environment to the human body)

All of these concepts ultimately impact trauma patients and their ultimate care (Ivancic, 2016). These three principles must guide accurate injury assessments. Kinetic and potential states of energy are fundamental physics-related ideologies which play a vital role in this energy potential.

Energy is in a potential state when at rest and an active state when in motion. Once an object or mass become mobile, the kinetic injury is formed.

These principles can apply to a motor vehicle. The vehicle is in a potential state at rest. This vehicle is now traveling along at a certain speed and strikes a tree or immovable object. The vehicle is in motion, and kinetic energy transfer will play a role through an impact sequence.

Impact Sequence

The first impact occurs when an immovable object impacts another object (such as a car vs. tree, pole, another parked vehicle, or guard rail), leading to the passengers being launched forward violently.

The second impact happens next when the car comes to an abrupt stop. The body then impacts with the inside of the car the steering wheel, the windshield, the seatbelt or airbag, or the roadway/environment if ejected.

Lastly, the third insult or impact to the body occurs when the internal structures such as organs and tissues collide with the body cavities. For example, the aorta may tear as it propels into the thoracic cavity or ribs may puncture a lung or spleen. Third impact or insults go to the essence of trauma assessment and determination of injuries based on this violent energy transfer.

Issues of Concern

Mechanism of injury is vital in determining energy potentials and subsequent, patterns of damage based on the extent of those impacts.

Impacts/Injury Patterns

- Frontal and near-side collisions lead to the steering wheel or dashboard impacts with front seat passengers.
- Head, neck, chest and abdominal injuries are expectations.
- Suspect pulmonary contusions and rib fractures with front end damage or near side impact (Weaver, Danelson, Armstrong, Hoth & Stitzel, 2013). Rib fractures tend to increase with age.
- Patient weight and body mass index (BMI) have a positive correlation with likelihood of injury (Mukherjee, Beck, Yoganandan & Rao, 2015).
- Improperly worn safety belts or unrestrained individuals can add to the risk of a lower extremity, pelvic, and abdominal trauma (Santschi, Echavé, Laflamme, McFadden & Cyr, 2005).
- T-bone impacts can cause the occupant seated closest to the point of impact a multitude of problems with any intrusion.
- Intrusion crushes the occupant causing another impact, and if that's not enough, they get a double hit, by contact with the interior of the car and any personal items in the car.
- T-Bone or lateral impacts associated with aortic or organ shear injuries, as well as fractures of the pelvis, neck, clavicle, and skull on the impact side.
- Rear impacts increase the risk of flexion and extension injuries of the neck and chance fractures of the spine.

Clinical Significance

Multi-system trauma involvement is clinically significant in that it should carry a high index of suspicion with "t-bone" collisions. Rollover crashes may cause all of these impacts as mentioned above and violent insults to the body (Dobbertin, Freeman, Lambert, Lasarev & Kohles, 2013). As the roof intrudes into the passenger compartment, head injuries are probable. If ejected, an impact with the windshield, window, and roadway or object on the road further complicate an already complicated patient. High-speed motor vehicle collisions, like those seen on the interstates, have a high probability of multi-system trauma involvement.

Other Issues

Scene Assessment of Damage

A study conducted between 2007 and 2009, concluded that emergency medical services personnel do an excellent job of assessing roll over damage, but intrusion, deformity and safety belt use can be difficult to judge on scene unless an experienced investigator is present (Lerner et al., 2011). On scene, accurate assessments of damages and its correlation with injury potential are vital to the decision making process regarding transfer to an appropriate tertiary care facility or trauma center. An adverse outcome may occur if transfer to a designated trauma center falls outside the "Golden Hour" of trauma. Trauma center designation involves state and local involvement in the designation process and sole triage criteria required.

Trauma Center Designation

The American College of Surgeons (ACS) play a valuable role in the evaluation and trauma center verification process. Trauma centers range from Level one designation to a level five designation. Trauma center readiness is key to the allocation of resources involved in a successful treatment plan, resuscitative care and interdisciplinary of a complex trauma patient. Trauma care often takes on a multifaceted dimension with cultural, social and community ramifications.

Trauma Triage Guidelines/Allocation of Resources

In conclusion, mechanism of injury is the key to the successful creation of trauma triage guidelines through predictability of injury patterns and life-saving interventions. Studying injury patterns and population shifts afford us valuable data to assist in the assuage of circumstances leading up to a motor vehicle crash with prevention techniques, treatment changes as well as legislation focused on improving negative outcome potential and car manufacturer safety guidelines related to airbags and safety belts (Ivancic, 2016).

As we go forth into the future, aging populations will represent a challenge in the allocation of resources both financially and medically for hospitals, long-term care facilities, and communities (Lawson, Alexander, Daley & Enderson, 2011). Prevention, education, and legislation will have lasting ramifications on the healthcare continuum of the polytraumatized patient, finding their basis in research and evidence-based practice and policy changes. Reimbursement and fund allocation considerations will be a part of this decision-making process.

Questions

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References

1. Mukherjee S, Beck C, Yoganandan N, Rao RD. Incidence and mechanism of neurological deficit after thoracolumbar fractures sustained in motor vehicle collisions. J Neurosurg Spine. 2016 Feb;24(2):323-331. [PubMed: 26451664]
2. Ye X, Funk J, Forbes A, Hurwitz S, Shaw G, Crandall J, Freeth R, Michetti C, Rudd R, Scarboro M. Case series analysis of hindfoot injuries sustained by drivers in frontal motor vehicle crashes. Forensic Sci. Int. 2015 Sep;254:18-25. [PubMed: 26183693]
3. Gowing CJ, McDermott KM, Ward LM, Martin BL. Ten years of trauma in the 'top end' of the Northern Territory, Australia: a retrospective analysis. Int Emerg Nurs. 2015 Jan;23(1):17-21. [PubMed: 25455905]
4. Zonfrillo MR, Locey CM, Scarfone SR, Arbogast KB. Motor vehicle crash-related injury causation scenarios for spinal injuries in restrained children and adolescents. Traffic Inj Prev. 2014;15 Suppl 1:S49-55. [PMC free article: PMC4841261] [PubMed: 25307398]
5. Van Toen C, Melnyk AD, Street J, Oxland TR, Cripton PA. The effect of lateral eccentricity on failure loads, kinematics, and canal occlusions of the cervical spine in axial loading. J Biomech. 2014 Mar 21;47(5):1164-72. [PubMed: 24411098]
6. Sisimwo PK, Mwaniki PK, Bii C. Crash characteristics and injury patterns among commercial motorcycle users attending Kitale level IV district hospital, Kenya. Pan Afr Med J. 2014;19:296. [PMC free article: PMC4393968] [PubMed: 25883724]

7. Kaufman RP, Ching RP, Willis MM, Mack CD, Gross JA, Bulger EM. Burst fractures of the lumbar spine in frontal crashes. Accid Anal Prev. 2013 Oct;59:153-63. [PubMed: 23792614]
8. Dobbertin KM, Freeman MD, Lambert WE, Lasarev MR, Kohles SS. The relationship between vehicle roof crush and head, neck and spine injury in rollover crashes. Accid Anal Prev. 2013 Sep;58:46-52. [PubMed: 23689205]
9. Pintar FA, Yoganandan N, Maiman DJ, Scarboro M, Rudd RW. Thoracolumbar spine fractures in frontal impact crashes. Ann Adv Automot Med. 2012;56:277-83. [PMC free article: PMC3503432] [PubMed: 23169137]
10. Weaver AA, Danelson KA, Armstrong EG, Hoth JJ, Stitzel JD. Investigation of pulmonary contusion extent and its correlation to crash, occupant, and injury characteristics in motor vehicle crashes. Accid Anal Prev. 2013 Jan;50:223-33. [PubMed: 22575308]
11. Lerner EB, Cushman JT, Blatt A, Lawrence RD, Shah MN, Swor RA, Brasel K, Jurkovich GJ. EMS Provider assessment of vehicle damage compared with assessment by a professional crash reconstructionist. Prehosp Emerg Care. 2011 Oct-Dec;15(4):483-9. [PMC free article: PMC3163749] [PubMed: 21815732]
12. Yoganandan N, Pintar FA. Odontoid fracture in motor vehicle environments. Accid Anal Prev. 2005 May;37(3):505-14. [PubMed: 15784204]
13. El-Hennawy H, El-Menyar A, Al-Thani H, Tuma M, Parchani A, Abdulrahman H, Peralta R, Asim M, Zarour A, Latifi R. Epidemiology, causes and prevention of car rollover crashes with ejection. Ann Med Health Sci Res. 2014 Jul;4(4):495-502. [PMC free article: PMC4160669] [PubMed: 25221693]
14. Dobbertin KM, Freeman MD, Lambert WE, Lasarev MR, Kohles SS. The relationship between vehicle roof crush and head, neck and spine injury in rollover crashes. Accid Anal Prev. 2013 Sep;58:46-52. [PubMed: 23689205]
15. Lawson CM, Alexander AM, Daley BJ, Enderson BL. Evolution of a Level I Trauma System: changes in injury mechanism and its impact in the delivery of care. Int J Burns Trauma. 2011;1(1):56-61. [PMC free article: PMC3415944] [PubMed: 22928159]
16. Anderson SA, Day M, Chen MK, Huber T, Lottenberg LL, Kays DW, Beierle EA. Traumatic aortic injuries in the pediatric population. J. Pediatr. Surg. 2008 Jun;43(6):1077-81. [PubMed: 18558186]
17. Kuan JK, Kaufman R, Wright JL, Mock C, Nathens AB, Wessells H, Bulger E. Renal injury mechanisms of motor vehicle collisions: analysis of the crash injury research and engineering network data set. J. Urol. 2007 Sep;178(3 Pt 1):935-40; discussion 940. [PubMed: 17632156]
18. Santschi M, Echavé V, Laflamme S, McFadden N, Cyr C. Seat-belt injuries in children involved in motor vehicle crashes. Can J Surg. 2005 Oct;48(5):373-6. [PMC free article: PMC3211905] [PubMed: 16248135]
19. Stefanopoulos N, Vagianos C, Stavropoulos M, Panagiotopoulos E, Androulakis J. Deformations and intrusions of the passenger compartment as indicators of injury severity and triage in head-on collisions of non-airbag-carrying vehicles. Injury. 2003 Jul;34(7):487-92. [PubMed: 12832173]
20. Nirula R, Mock C, Kaufman R, Rivara FP, Grossman DC. Correlation of head injury to vehicle contact points using crash injury research and engineering network data. Accid Anal Prev. 2003 Mar;35(2):201-10. [PubMed: 12504141]
21. Phillips BJ, Turco LM. Le Fort Fractures: A Collective Review. Bull Emerg Trauma. 2017 Oct;5(4):221-230. [PMC free article: PMC5694594] [PubMed: 29177168]
22. Ivancic PC. Mechanisms and Mitigation of Head and Spinal Injuries Due to Motor Vehicle Crashes. J Orthop Sports Phys Ther. 2016 Oct;46(10):826-833. [PubMed: 27594659]
23. Al-Madani HMN. Global road fatality trends' estimations based on country-wise micro level data. Accid Anal Prev. 2018 Feb;111:297-310. [PubMed: 29253755]

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