North Memorial
Trauma Update
North Memorial Medical Center is a *Level I Trauma Center*

North Memorial

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Welcome to the fourth edition of the *North Memorial Trauma Update*. This peer reviewed educational newsletter, written by the trauma surgeons at North Memorial, is published on a quarterly basis. One of the goals of a Level 1 Trauma Center is to provide quality trauma education to providers caring for injured patients. In 2009 we will start with a discussion of mechnisms of injury. Future editions will cover care related to injury of specific anatomical regions and organ systems of the body.

To receive one AMA PRA Category 1 Credit(s),™ answer the questions on the postcard inserted in the newsletter and return to the address printed on the front. If you would prefer to receive *North Memorial Trauma Update* by email in the future, please send an email to: traumaupdate@northmemorial.com.

Mechanisms of Trauma

We previously addressed the initial assessment as well as the use of radiographic and laboratory tests to assess trauma patients. In this issue we focus on mechanisms of injury. Trauma has traditionally been categorized as *blunt* (motor vehicle collisions (MVC), falls etc.) or *penetrating* (impalement, stabbings and firearms). Stab wounds are typically low energy with injury limited to the structures traversed by the penetrating object. In injuries such as falls, MVCs and gunshot wounds (GSW) the transfer of kinetic energy (KE), energy present in all moving objects, is a major determinant of the magnitude of the injury. KE which is equal to $\frac{1}{2}$*Mass*Velocity^2 = $\frac{1}{2}mV^2$ has traditionally been used to characterize GSWs but is also relevant for blunt trauma.

QUESTION #1:
Factors which are important in determining the amount of tissue damage from bullet wounds include which of the following?

A. Mass of the bullet
B. Velocity of the bullet
C. Yaw of the bullet
D. Thickness of the body part
E. All of the above

Bullets cause injury by crushing tissues in the direct path of the projectile, the *permanent cavity*, by the blast effect resulting in *temporary cavitation*, which often includes a zone of tissue that is significantly greater than the volume of the permanent cavity. Additionally, *secondary missiles* produced by bullet fragmentation or fragments formed by the bullet striking other objects such as bone can extend the area of injury. For a GSW velocity is the dominant factor. For example, a 22 long rifle round with a mass of 2.7 grams and a muzzle velocity of 342 meters/second contains a KE of 315.8 joules while a M16 round has a mass of 3.6 grams but a muzzle velocity of 843 meters/second and thus possesses considerably more KE, 2312 joules and thus produces considerably more injury. Another factor that increases tissue damage is yaw, rotation of the bullet around its short axis. Yaw typically occurs as the bullets strike soft tissue. As yaw reaches 90 degrees the bullet moves through the tissues sideways producing the maximal amount of crush injury. The next contributing factor is bullet mushrooming, which results in the diameter of the bullet increasing and the center of mass

continued on page 2

of the bullet moving forward so that there is little if any yaw. This is more typically seen in handgun rounds and produces a smaller increase in profile than larger bullets which develop yaw. This explains why handguns typically produce less tissue damage than hunting and military rifles.

MOTOR VEHICLE CRASHES

QUESTION #2:
In motor vehicle crashes which of the following are important determinants of injury?

A. Speed of vehicles at the time of impact
B. The angle of impact
C. Bumper height
D. Difference in mass of the two vehicles
E. All of the above

MVCs produce injury based on the transfer of KE between the vehicle and passenger. The *primary impact* is the initial impact between the two vehicles or the vehicle and another fixed structure. This is followed by a *secondary impact* in which the occupant of the vehicle strikes the interior of the vehicle or a fixed object outside of the vehicle if the passenger is ejected. Occupants who are ejected from the vehicle are often grouped with individuals involved in crashes involving motorcycles, bicycles and all terrain vehicles as these offer little protection for the patient particularly as related to an increased risk of spine injury.

Modern vehicles protect occupants by reducing the magnitude and rate of energy transfer from the primary impact to the occupant. Without restraints a frontal impact typically results in the initial transfer of energy to the lower extremities into the floor or dashboard, producing fractures in the lower extremities, followed by the chest striking the steering wheel, and then the head striking the windshield. When the chest and upper abdomen strike the steering wheel injury to the liver and pancreas may occur, while the head striking the windshield places the patient at risk for a traumatic brain injury. Given these observations it is clear how the use of restraints reduces the incidence of traumatic brain injury. Paradoxically seatbelts are associated with an increase in intra-abdominal injuries. This is due in part to the fact that many wear their seat belts across their abdomen rather than iliac crests thus increasing the risk compression injury to the abdominal contents. Airbags slow the rate of deceleration but have been problematic for individuals who sit close to the steering wheel, as they can suffer injury from the direct impact of their airbag inflation. This may produce C-spine and ocular injuries as well as thermal and alkali burns. More recently the rate of air bag inflation has been reduced and these forms of injury are seen less commonly.

QUESTION #3:
Front, rear and side impact crashes have similar patterns of injury?

A. True
B. False

The rate of energy transfer is also reduced by crush zones, areas in vehicles which deform on impact resulting in a more gradual transition between the primary impact and the secondary impact. Crush zones are typically more effective in the front and rear portions of the vehicles than in the sides of vehicles, thus all things otherwise being equal (e.g. mass difference between the two vehicles and speed of impact) a side impact will produce more severe injury than a frontal impact.

Side impacts typically produce injuries by direct impact or intrusion into the vehicle. Important factors are speed at impact, difference in mass of the vehicles and height of the bumper. These facts help explain why occupants of a sedan hit broad side by a SUV will typically have more severe injuries as well as more injuries to the head, neck and upper torso while those struck broad side by a similar sized sedan will have more pelvic and lower extremity trauma. When hit by a vehicle of similar mass, the direction of impact (front vs. side) and speed are the major determinants of injury. Typically injury severity increases significantly when the speed at impact exceeds 30 mph.

In rear impacts the initial acceleration leads to hyperextension of the head followed by rebound flexion or whiplash. This is prevented or reduced by the presence of properly adjusted head restraints.

QUESTION #4:
Which of the following is false?

A. Passengers in a car struck by a SUV are more likely to suffer thoracic and head injuries.
B. In rollover crashes the integrity of the vehicle's role cage and the use of restraints by all passengers is important for reducing the severity of injury
C. Side impact crashes produce less severe injuries than head on crashes
D. Adult pedestrians struck by a car are likely to suffer a triad of injuries (lower extremity, torso and head and neck)
E. Child pedestrians struck by a car are more likely to have traumatic brain injury

In the case of rollover crashes, injuries are affected by the ability of the vehicle's role cage to prevent crush injury and the use of restraints. In all forms of MVCs, but especially in rollover crashes, unrestrained occupants of the vehicle can cause additional injury to restrained passengers in the

car. In these cases a clear pattern of injury has not been consistently demonstrated.

In summary, MVCs are more likely to result in injury when there is a side impact, crashes occur at speeds in excess of 30 mph and crashes in which there is significant disparity in the mass or bumper heights of the vehicles. There will often be more head and thoracic injuries in occupants of cars hit by a SUV particularly if there is a side impact.

When an adult pedestrian is struck by a motor vehicle, injuries occur in three phases: Bumper impact with the lower extremity; impact of the torso with the hood and windshield of the vehicle followed by rolling over the vehicle and striking the ground at which time injury to the head and C-spine occur. In contrast children are more likely to suffer brain injury from a direct impact with the bumper or grill of the car.

QUESTION #5:
Which of the following is correct?

A. When a car is hit broadside by a SUV the difference in mass between the vehicles but not the bumper height is an important determinant of the pattern of injury
B. The use of helmets by bicyclists reduces the incidence of head injury but does not alter mortality of the bicyclist
C. The speed that the cyclist is riding has little impact on the likelihood of the cyclist sustaining injuries in a crash
D. Hepatobiliary and pancreaticoduodenal injuries are more likely to occur when the cyclist strikes the handle bar with their abdomen

The final category of injuries, that we will discuss, are those related to bicycle crashes in which injuries are more likely to occur when the cyclist is struck by a motor vehicle (associated with a 14 fold increase in the fatality rate) or if the cyclist is traveling at speeds in excess of 15 mph. The use of helmets is associated with a 93% reduction in mortality. Specific patterns of injuries that are more commonly seen in bicycle crashes are hepatic and pancreaticoduodenal injuries when the abdomen strikes the handle bar and genital and rectal injuries when there is impact with the seat post and saddle.

Answers: 1-E; 2-E; 3-B; 4-C; 5-D

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2009 CME Opportunity

ATLS (Advanced Trauma Life Support)

June 11-12, Oct. 22-23, Dec 3-4, 2009

This program was developed by the *American College of Surgeons Committee on Trauma* and is designed to assist physicians in providing the first hour of emergency care to trauma patients. Training combines didactic lectures and practical skills stations, allowing time to perfect skills in the initial assessment; and management and stabilization phases of trauma patients.

For more information and to register online for classes, please go to cmetracker.net/NM/catalog.

For questions please call (763) 520-7274.

2009 Trauma Nursing Education

Trauma 101

April 20, 2009

Designed to cover the basics of traumatic injuries and the care of the injured patient.

Trauma 201

October 26,2009

Designed to build on the basics presented in Trauma 101. Discussions and case presentations on the critical care needs of the injured patient. Trauma 101 is strongly recommended as a prerequisite to this class.

For registration and/or questions, please call (763) 520-5940 or email, ce@northmemorial.com

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