Trauma Overview
TRAUMA

What is trauma?

Trauma results when an external physical force is applied to the body. This can occur in a variety of ways – a motor vehicle accident, a fall, a gunshot wound. The type and severity of injuries are determined by the physical features of the energy – how far, how fast, how much velocity, and so on.

Specific types of physical force can result in predictable mechanism of injury patterns. A person who falls from height and lands on her feet is likely to have certain types of injuries, as will a person who is the unrestrained driver in a car versus pole accident.

Clinical indicators and environmental clues can also help you evaluate trauma, particularly in those situations where the force and mechanism of injury are difficult to discern. A man lies at the base of a ladder – how far did he fall? A woman presents with a small puncture wound to her abdomen – what type of object was used and how far was it inserted?

In this overview, we’ll consider how physical force, mechanism of injury profiles, and clues from the environment and the patient presentation can help you anticipate the patient’s injuries and make the most appropriate assessment, treatment, and hospital destination decisions.

Laws of Energy

The laws of energy can explain how people may be injured based on the forces that they have sustained. These forces are equally valid for a patient who is in a motor vehicle accident, suffers a fall, or is the victim of an assault. The laws of physics are universal, and it is those laws that explain the forces that are experienced by a person who has been injured.

**Newton’s 1st Law of Motion** states that an object at rest stays at rest, and an object in motion stays in motion and at the same speed, until acted upon by another force or object.

For example, a passenger in a vehicle moving at 60 miles per hour does not feel like they are moving at 60 miles per hour relative to the speed of the vehicle. If the vehicle strikes an immovable object, coming to a sudden stop, the passenger is still moving at 60 miles per hour until they are stopped by an immoveable object (the steering wheel.) Similarly, the internal organs of the passenger are moving at 60 miles per hour until they, in turn, are stopped by an immoveable object (the sternum.)

Another example is a patient sitting in a stopped vehicle that is struck from behind. The vehicle may be pushed forward, while the tendency of the person, and the person’s neck and head, is to remain stopped, resulting in “whiplash” type injuries.

**Newton’s 2nd Law** states that the force acting on an object = mass of the object times the acceleration or deceleration of the object (F = MA).

In other words, it is the change in velocity with respect to time that generates the forces that cause injury. An example would be a vehicle moving at 60 mph that is stopped suddenly by impact with an immovable object, going from 60 mph to 0 miles per hour. This can generate
a force 300 times greater than a passenger’s body, on that body. This explains why seat belts and air bags help reduce injuries; while the person’s body still goes from 60 miles per hour to 0 miles per hour, these devices provide a longer period of deceleration, thus reducing the force experienced by the person.

**Newton’s 3rd Law** states that for every action there is an equal and opposite reaction.

Returning to the vehicle moving at 60 miles per hour and suddenly stopping when it hits an immovable object, Newton’s third law states that there are forces generated from the vehicle hitting the pole and there are opposite forces that are generated back from the pole to the vehicle, passenger, and internal organs. This is why a collapsed steering wheel or a dent in the hood of a car that has struck a pedestrian are concerning; the force that has caused this damage to the vehicle is the same force experienced by the part of the body that has struck it.

**The Law of Kinetic Energy** (Law of Motion) explains the relationship between the mass of an object and the velocity or speed at which it is traveling. This is stated in a formula: Kinetic energy = ½ mass or weight of an object times its velocity squared (KE = ½MV²).

Simply stated, the energy that results in injuries doubles when the weight doubles but will quadruple when the velocity doubles. For example, consider a person injured by a bullet from a high velocity rifle. When the velocity of a bullet doubles, the energy and therefore the potential damage can quadruple. Often these injuries are hidden. Therefore when possible, try to determine what type of weapon was used, as this may provide some clues as to the type and extent of injuries.

**Case Study 1: Energy and trauma**

EMT Josh is dispatched to a single car motor vehicle accident, car into a light pole in a parking lot (estimated speed 10 mph). His patient is a 19-year-old male complaining of pain on his left side. Vitals are: blood pressure 120/80, heart rate 80, respiratory rate 18.

EMT Lisa is dispatched to a single car motor vehicle accident, car into a light pole on a highway (estimated speed 60 mph). Her patient is a 19-year-old male complaining of pain on his left side. Vitals are: blood pressure 120/80, heart rate 80, respiratory rate 18.

Most EMTs will recognize that Lisa’s patient is probably more severely injured than Josh’s patient – even though the two may present with identical, relatively minor complaints and normal vital signs. We appreciate that even badly injured patients may initially have normal vital signs and minor complaints, especially if they are young and healthy or if alcohol or drugs blunt their perception of pain.

In these cases, the apparent forces acting on the Lisa’s patient may be enough to raise your index of suspicion that the patient may be critically injured. In fact, an evaluation of these forces is the first step in the High Performance Trauma Management (HPTM) process.
MECHANISM OF INJURY PROFILES

Mechanism of injury describes the way that traumatic injuries occur. Mechanism of injury allows the EMT to use the laws of energy to anticipate the severity and types of injuries that may occur after trauma. This concept is especially useful in evaluating those patients who may not have obvious life-threatening injuries or unstable vitals.

Case Study 2: Mechanism of injury

You are called to evaluate a 64-year-old male who was struck by a full sized pickup truck. Witnesses state that the car was traveling close to the posted speed limit of 40 mph, and the patient was thrown approximately 20 feet. There is a large indentation on the hood of the truck.

You arrive to find the patient sitting on the curb, awake and alert. He says he feels “sore” and that “the wind was knocked out of me,” but he has no obvious external injuries. His vitals are blood pressure 128/80, heart rate 64, respiratory rate 20. He says he just wants to go home.

Mechanism of injury and your knowledge of the laws of energy tell you that the patient is at significant risk of serious injuries. You request a medic evaluation, and the paramedics transport the patient to the local trauma center. He is found to have three broken ribs, a pulmonary contusion, and a liver laceration. He is treated, admitted, and ultimately discharged about a week later.

To understand mechanism of injury, it helps to consider different types of trauma. Trauma can be loosely divided into blunt trauma (such as injuries from a motor vehicle accident) and penetrating trauma (such as a shooting or stabbing). Other types of trauma including blast injuries and burns, may not fit cleanly into these categories.

BLUNT TRAUMA

Blunt trauma can occur from motor vehicle accidents, falls, being struck by a vehicle, assaults, and blast injuries.

Motor vehicle accidents

Three impacts occur in a typical motor vehicle accident.

The first impact occurs when the car hits another car, tree, or other object. Cars are designed to absorb the forces of impact as much as possible, so there may be significant deformation of the vehicle. Significant damage to the vehicle implies significant force and therefore a likelihood of significant injury. Pay particular attention to vehicle damage in the area of the patient, such as a crumpled steering column or intrusion into the driver or passenger compartment.
The **second impact** occurs when the patient collides with the inside of the now stopped vehicle. This impact may cause lower leg fractures as the patient hits the dashboard, rib fractures as the patient hits the steering wheel, and facial fractures and head injuries as the patient collides with the windshield or side posts. Occasionally a patient is ejected from the vehicle and strikes the ground, a tree, or other objects – an impact that is often predictive of severe injuries.

Less obvious but just as serious are the injuries resulting from the **third impact**. When the patient’s body hits the inside of the vehicle in the second collision, the patient’s internal organs are still moving. The third collision occurs when those organs strike the now-stopped body. This may result in tears, stretching, or bruising of the tissues of the brain, lung, liver, and big vessels such as the aorta.

The injuries caused by these impacts vary depending on the type of accident and may include:

**Front-end Collisions**

Check for airbag deployment and seatbelts, both of which may decrease the severity of the second and third collisions by slowing down and cushioning the impact. Extremities may not be protected, so there may be trauma to the arms and legs. Children may be seriously injured by airbags, and even adults may suffer bruising or abrasions from contact with the airbag as it deploys.

Unrestrained drivers may impact the steering wheel with the chest or face. Passengers may impact the windshield. Either drivers or passengers may impact the dashboard with their knees, transmitting forces up into the pelvis. Unrestrained backseat passengers may be thrown forward to impact the dashboard, windshield, or the people in the front seat.

**Rear-end Collisions**

Forces from the rear cause whiplash-type injuries as a person’s body is pushed forward, while the heavier head lags behind. There may be injuries to the back or neck. There may also be injuries from the third collision as the brain impacts the inside of the skull.

Try to determine the speed of the vehicles, the extent of damage, and whether there is intrusion into the vehicle.

**Lateral Collisions**

Lateral or T-bone collisions have the potential to cause serious injury. Like a rear-end collision, an impact from the side may push the body away from the force, while the head lags behind, causing a side-to-side whiplash effect. Head, torso, abdomen and pelvis may also be injured by intrusion into the vehicle compartment.
Look for such intrusion into the vehicle as well as the presence of side curtain airbags, which can help protect the person from these forces.

**Rollover Collisions**

Rollover crashes are particularly deadly for people who are not restrained and who may suffer an unpredictable pattern of injury as they are bounced from one surface to another inside the vehicle. The greatest risk of death and significant injury occurs in people who are partially or completely ejected from the vehicle. They may suffer trauma from impact with trees or the ground, or may be crushed by the vehicle as it rolls.

Restrained occupants in rollover crashes with no intrusion are often protected from major injuries. However, even a restrained person can still impact the roof during the roll-over, resulting in a head or neck injury.

When possible, try to determine the number of rolls, the speed at which the vehicle was traveling, and whether the vehicle’s rolling was stopped by another object such as a tree.

**Pedestrians, Bicyclists, and Motorcyclists**

Vehicles that strike pedestrians, bicyclists, or motorcyclists impact a huge force onto a relatively unprotected person. Even at low speeds, the injuries can be significant.

Try to determine the speed at which the vehicle was traveling, and examine the vehicle for damage. The presence of contact points across the hood and on the windshield, for example, indicates that the patient was tossed upward by the force of the impact. If the patient is some distance from the vehicle, try to determine if he was thrown that distance.

Consider the possibility that the patient may also have been struck and run over by the vehicle. In the unfortunate case of a hit-and-run, gather as much information as possible from bystanders. Look on the road for clues such as clothing, shoes or broken glass to gauge the place of impact and possible speed.

For bicyclists, consider if there is a helmet, but recognize that while a helmet offers some protection, it will not completely prevent head injuries. It offers no protection for other types of injuries.

Unlike bicyclists, motorcyclists can travel at highway speeds, but without the protection of a car. A motorcycle may impact a car, a stationary object, or the ground, and the rider may be ejected from his motorcycle after the initial impact. Leathers can provide protection from abrasion, but not from blunt trauma or from a crushing injury that may occur when the rider is trapped between the motorcycle and a fixed object. The presence of a helmet should be noted, but again is not totally protective if there is a significant force.

**Falls**

The height, the surface, and the position are the major determinants of injury in patients who fall.

Any fall greater than 15 feet or more than 3 times that patient’s height is considered significant. The force of the patient impacting the ground may cause blunt trauma injuries in
much the same way as a patient involved in a motor vehicle accident. Patients who land on their feet may suffer broken legs and broken or dislocated hips as the force is transmitted upwards. The most devastating injuries occur in patients who land on their heads.

Concrete or other hard surfaces cause the most significant injuries. Patients whose fall is broken by shrubbery may be lucky enough to escape serious injury.

Patients who are older are at higher risk from all trauma, including falls. A fall from standing in an older adult may cause fractures and other injuries.

Lastly, regardless of the height, consider the cause, whether it was a syncopal episode in the case of an older adult falling from a standing position, or a suicide attempt in a fall from height.

**PENETRATING TRAUMA**

By definition, penetrating trauma consists of injuries that occur when an object penetrates the skin. However, the extent of the damage may go far beyond the obvious, as the energy travels through the soft tissue of the body. Even a tiny incision from a knife can be fatal if the knife punctures the heart, lungs, liver, or great vessels.

Injuries from gunshots or knives come to mind when thinking of penetrating injuries, but remember that such injuries can also be caused by other items such as scissors or sharp metal after a car crash. Occasionally patients fall or otherwise impale themselves on objects that cause penetrating wounds.

Learn as much as you can about the penetrating object. If a gun, what is the caliber? If a knife, how long was it? If the knife or other sharp object was recovered, you may be able to see a fat or blood line that indicates how far the knife was inserted. Be careful not to touch these weapons as it may interfere with the police investigation.

The path of a projectile such as a bullet inside the body is not necessarily a straight line. Bullets can roll, ricochet off bones, and produce a wave of pressure that causes additional damage. Also, some bullets are designed to fragment, with each piece causing more injury. Even a knife wound can be misleading. A small incision in the upper abdomen can actually result from a knife that was driven upward into the lung.

Penetrating injuries are easy to miss. A life-threatening injury can have a very small wound with minimal exterior bleeding. It’s essential to do a complete physical exam of the entire body, front and back, and locate all wounds. It may not be possible to distinguish between an entry and an exit wound. Simply note the number and location of injuries.
Case study 3: Mechanism of injury

You are called to the scene of a rollover accident. Witnesses state that the car was exiting the freeway and failed to negotiate the ramp, rolling at least twice before striking a concrete abutment with the rear of the vehicle.

The car is on its wheels and you find your patient, a 22-year-old unrestrained female, lying across the back seat. She is conscious but confused, and smells strongly of alcohol. She is complaining of pain on her left side and across her abdomen. Her vitals are blood pressure 90P, heart rate 130 and respiratory rate 22.

What injuries do you suspect in this patient? An unrestrained patient in a rollover accident is at high risk of serious, but often unpredictable injuries, as she impacts different parts of the vehicle during the roll. Furthermore, this car struck a concrete abutment with the rear of the car, causing yet another impact to the patient.

Paramedics treated and transported this patient to the nearby trauma center, where she was found to have a concussion and a spleen laceration.

Case study 4: Mechanism of injury

You are called to the scene of a two-car accident in which a large pickup truck went through a red light at a high rate of speed and struck a small passenger car in the driver’s side door. The driver of the car was restrained but there was no airbag deployment. There is significant damage and intrusion into the driver’s side.

Your patient is a 45-year-old male who is unconscious. You note abrasions and swelling on the left side of the head and a deformity to the left upper arm. The patient’s vitals are blood pressure 82 by Doppler, heart rate 136, respiratory rate 18 and irregular.

How does the mechanism of injury explain this patient’s presentation? The patient likely suffered head trauma due to the impact of his head as well as the rest of his body against the side of the door. The broken upper arm reflects the force of the collision.

What other injuries might you suspect? A lateral impact on the left side also put the patient at risk of a pelvic fracture, femur fracture, spleen laceration, and abdominal injuries. Bleeding from these injuries could explain the patient’s hypotension.

Paramedics transported this patient to the trauma center where he was found to have a skull fracture and brain injury, a fractured humerus, a pelvic fracture, and a spleen laceration. He spent over a month in the trauma ICU, but made a slow but eventual recovery.
ENVIRONMENTAL CLUES

Assessing the scene for mechanism of injury goes beyond applying the physics of trauma to a damaged vehicle. It is also useful to look at and around the scene for environmental or other clues. Consider a single car crash in which a 75-year-old male’s car slid into a ditch beside the road under dry daylight conditions. Did the patient fall asleep? Suffer from a medical condition such as a heart rhythm abnormality or low blood sugar? Similarly, consider the teenage driver who lost control of his car on a curve. Did she take recreational drugs? Or perhaps she was texting and got distracted?

Some of this information may be gleaned from the patient. You may be able to obtain other clues from careful examination of the scene. Information such as this can often be very useful both for the paramedics and for the physicians at the hospital.

CLINICAL INDICATORS

Mechanism of injury is a critical first step in evaluating a traumatized patient. You can often make this assessment before you lay eyes, or hands, on the patient.

However there are cases where mechanism of injury is unknown and you must rely on your ability to assess a patient and recognize the clinical indicators that suggest significant trauma. As you perform your assessment, keep the SICK/NOT SICK criteria in mind.

Consider the following steps to your exam as you quickly evaluate a trauma patient:

Patient position

Observe the patient as you approach.

- What is the person’s position and is he or she moving?
- What does this suggest about the type or severity of injury?
- Is the patient located a distance from the vehicle, ejected, or he is mobile at the scene?
- Is the patient motionless, unconscious? There may be a spine injury.
- Is the patient sitting up? Leaning forward? Is he or she short of breath?
- Is the patient hunched over or curled up? Check for abdominal pain.
- Is the patient posturing with any abnormal position or movement? There may be a head injury or a seizure.

Respirations

Observe the patient for adequate rate, respiratory effort, use of accessory muscles, and lung sounds. Be prepared to assist with ventilations or place the patient on high flow oxygen if indicated. What does the patient’s respiratory status suggest about his or her injury?

- Is the respiratory rate absent?
- Is the respiratory rate too fast? There may be shock, hypoxia or anxiety.
- Is the respiratory rate too slow? There may be a head injury or an overdose.
- Is the respiratory rate irregular? There may be a head injury.
• Is the airway obstructed? There may be blood, vomit, food or an anatomical obstruction.
• Are there unequal breath sounds? There may be pneumothorax or hemothorax.

Skin Signs and Pulse
Feel for a radial pulse and assess the patient’s skin. What do the pulse and skin signs suggest about the severity of the patient’s injuries?

• Is the patient pale, diaphoretic, cyanotic? There may be shock, hypoxia or hypothermia.
• Is the patient’s pulse rate thready? The patient may be hypotensive, peripherally vasoconstricted or have poor peripheral circulation.
• Are peripheral pulses unequal? There may be injury to one extremity, injury to the aorta or another major vessel, or it may be normal for this patient.

Mental Status
Mental status is a key component of the SICK/NOT SICK evaluation criteria. Can the patient follow a simple command such as “stick out your tongue” or “squeeze my hand”? A person who is able to follow commands is usually also able to protect his or her airway.

Frequent rechecks of mental status can determine if a patient is deteriorating. Mental status may range from alert and oriented, to responsive to verbal or painful stimuli, to unresponsive. The Glasgow Coma Score allows the EMT to measure a patient’s mental status. Altered mental status has a variety of causes in the trauma patient, ranging from a head injury to hypoxia to hypoglycemia to drug or alcohol use.

Remember that altered mental status often progresses to impaired respiratory drive. Be prepared to support the patient’s respirations.

Gut Feel
Gut feel is an important component of the SICK/NOT SICK criteria. An experienced EMT will occasionally consider a patient SICK and request a medic evaluation even in the absence of significant mechanism of injury or abnormal vital signs. Often the EMT has picked up on something abnormal, such as an unusual complaint or something that seems out of place. An example would be a patient who is acting restless, a possible early sign of shock.

In addition, a variety of other factors can potentially elevate a patient from the NOT SICK to the SICK category. Take extra care when evaluating the following special patients and don’t hesitate to upgrade the patient if indicated:

• Very elderly or very young patients
• Patients who are pregnant, particularly those in the third trimester
• Patients with significant medical problems such as diabetes, osteoporosis, or respiratory problems
• Patients who are taking anti-coagulant medications such as Warfarin or Coumadin that might increase their risk of serious bleeding
Patients who are intoxicated, since their perception of pain and other symptoms may be impaired

**Case Study 5: Clinical indicators**

You are called to the scene of an injured person. You arrive to find a 20-year-old male on the sidewalk in front of a parking garage. Witnesses found the patient on the ground. There is no indication about what caused his injuries.

The patient is semi-conscious, combative, with a large hematoma on the back of his head. There are open fractures of both lower legs. The pelvis feels unstable. The vitals are: blood pressure 80P, heart rate 150 and respiratory rate 28 and irregular.

Without any knowledge of the mechanism of injury, this patient is clearly badly traumatized. What mechanism of injury might result in bilateral lower leg fractures, an unstable pelvis, and a head injury?

As you are beginning to package the patient for the arrival of the medic unit, a security guard tells you that he has found a suicide note on a car on the 6th floor of the parking garage. Based on this information and the patient’s injuries, it is likely that this patient jumped, landing on his feet initially and then falling backwards, striking the back of his head.

Paramedics transported this patient to the trauma center, but he suffered devastating neurologic damage and did not survive.

**HIGH PERFORMANCE TRAUMA MANAGEMENT**

**Why High Performance Trauma Management?**

The laws of energy, mechanism of injury profiles, and clues from the environment and the patient presentation can help the EMT determine the likelihood of serious injury in a trauma patient. This is the first step of a cohesive approach to the assessment, treatment, and transport of trauma patients, called High Performance Trauma Management (HPTM).

The driving force behind HPTM is to provide the highest level of care to a trauma patient while focusing on minimizing scene time and transporting the patient as quickly as possible to the closest appropriate hospital. Ideal on-scene time in high trauma events is less than fifteen minutes.

Critically injured trauma patients need evaluation and treatment of immediately life-threatening problems at the scene, but definitive care can only be done at the hospital, and in many cases, in the operating room. Therefore, all actions at the scene should be directed towards the goal of getting the patient to that definitive care as quickly as possible.

While this may seem obvious, it is a departure from the way we treat some other patients at the scene. For example, patients in cardiac arrest or those with congestive heart failure are often stabilized by paramedics before transport. A patient with a less serious injury, such as a minor burn or twisted ankle, may be left at home or transported by family members to a
Recognize. But for the critically injured trauma patient, whether they are suffering from blood loss, a pneumothorax, or a head injury, the focus must be on the final goal of definitive, in-hospital care.

High performance trauma management encompasses four components: recognition, treatment, packaging, and transport.

- **Recognition** - based on the mechanism of injury and patient presentation, EMTs must identify those patients who will benefit from a high performance trauma response.
- **Treatment** - for those identified as trauma patients, the EMT must provide treatment for immediately life-threatening problems, such as bleeding or airway problems.
- **Packaging** - the trauma patient must be prepared for transport as quickly and efficiently as possible. Have the patient ready for a smooth handoff to paramedics.
- **Transport** – in most cases, paramedics will rapidly transport the patient to the appropriate designated trauma facility.

### Case Study 6: Putting it all together: HPTM

You arrive on the scene of a 19 year old male who has been stabbed once in the upper left quadrant and once in the upper left arm. He is awake and alert, lying very still, breathing rapidly. There is a pool of blood forming under his arm. His vitals are: BP 108P, HR 140, R 30. The police show you the knife, which is about 6 inches long, with about 4 inches of blood and fat along the blade.

Your HPTM plan is as follows:

- Recognition – any knife wound with penetration to “the box” (chest or abdomen) is significant; additionally, your patient is bleeding from a stab wound to the arm. You also recognize based on the mechanism of injury that the patient’s stab wound to the abdomen may also have injured the lung. You prepare to support the patient’s respiratory effort if needed.
- Treatment – any life-threatening problems must be corrected immediately. You begin direct pressure on the arm until the bleeding stops. You notice the patient’s respiratory distress and place the patient on high-flow oxygen. You confirm that a medic unit has been dispatched and you update them on the patient’s condition.
- Packaging – you appreciate that definitive treatment for trauma can only occur in a hospital. You begin to package the patient for the arrival of the medic unit, so that he can be brought to the medic unit as soon as they arrive
- Transport – the medics quickly start IVs, intubate the patient, and begin to transport. Total on-scene time was 13 minutes.

The patient was found to have a lacerated artery in the arm, a lacerated spleen, and a hemothorax. He was taken to surgery and then to the ICU where he made an excellent recovery.