

## Section 1

## Initial management of the trauma patient

## Chapter

## 1

## Mechanisms and demographics

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## Objectives

- (1) Describe the epidemiology and clinical importance of trauma in the United States and worldwide.
- (2) Describe the epidemiology of the most common traumatic mechanisms of injury.
- (3) Describe the injury patterns seen within these common traumatic mechanisms of injury.

## Introduction

Trauma is defined as bodily damage as a result of mechanical, chemical, thermal, electrical, or other energy that exceeds the tolerance of the body. Although trauma is often seen as “accidental,” in reality it should be viewed as a “disease” with modifiable risk factors (see Chapter 41). Data have shown that ~25% of trauma patients evaluated at a busy academic trauma center experienced a prior traumatic event and required evaluation in a hospital setting within the previous five years.<sup>1</sup> Statistics such as these confirm that trauma is not a random event affecting random people.

In 2009, within the United States, injury was the leading cause of death in people between the ages of 1 and 44. Overall, traumatic injury was the fifth leading cause of death for all age groups (Fig. 1.1).<sup>2</sup> Worldwide, an estimated 5 million people died from injuries in 2000 – a mortality rate of 83.7 per 100,000 population.<sup>3</sup> This mortality rate accounted for 9% of the world’s deaths. Traffic injuries accounted for 25% of these deaths, with homicide and suicide accounting for an additional 26% of deaths (Fig. 1.2).<sup>3</sup> The financial burden of trauma can also not be overlooked. In 2005, within the United States, fatal injuries resulted in \$1.6 billion in medical costs and a staggering \$164 billion in loss of work to society (Fig. 1.3).<sup>4</sup>

Traumatic injuries are often divided into unintentional and intentional mechanisms. Examples of unintentional mechanisms include motor vehicle and motorcycle collisions, pedestrians struck by a vehicle, and falls. Examples of intentional mechanisms include suicide and homicide. Both unintentional and intentional mechanisms can include penetrating causes such as gunshot wounds and stab wounds.

Unfortunately, both these unintentional and intentional injuries often involve substance abuse. Alcohol has been cited as a contributory factor in nearly 50% of traumatic injury deaths. The combination of drugs and alcohol with access to a deadly weapon often results in death or serious injury. Traumatic injuries can also cause posttraumatic stress disorder and result in initiation or worsening of substance abuse practices. Many trauma centers have recognized the association of substance abuse and traumatic injury and have implemented programs to assist with patient rehabilitation, but better data are needed to see if these programs actually decrease trauma recidivism.

## Trauma mechanisms

## Motor vehicle collisions

Motor vehicle collisions are the leading cause of death due to injury. In 2008, just over 100 people per day died on United States roads. Drivers under the influence of alcohol and drugs are significantly more likely to be involved in a motor vehicle collision and subsequently die from their injuries.<sup>5</sup> Estimates show that 32% of all fatal motor vehicle crashes involve alcohol. This number increases to 65% in fatal crashes between 12 a.m. and 3 a.m.<sup>6</sup> More recently, driver distractions from cellular phone and global positioning system (GPS) technology have been implicated in motor vehicle collisions. A Harris Interactive Health Day poll of 2810 adults conducted in November 2011 demonstrated that 37% had sent or received cellular text messages while driving, and 18% said they did so regularly.<sup>7</sup> This has prompted some states to introduce legislation to prohibit cellular phone text messaging while driving, in hopes of decreasing the number of motor vehicle collisions (see Chapter 41).

Injury patterns depend on the location of the impact and the presence or absence of protective devices. Frontal impacts of the down-and-under type result in lower extremity and pelvic fractures. The up-and-over type of frontal impact often results in chest, spine, and traumatic brain injuries. Lateral impact causes injuries to the chest and upper abdomen such as liver and spleen. Rear impact often results in cervical spine

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10 Leading Causes of Death by Age Group, United States – 2009

Rank	Age Groups										Total
	<1	1-4	5-9	10-14	15-24	25-34	35-44	45-54	55-64	65+	
1	Congenital Anomalies 5,319	Unintentional Injury 1,466	Unintentional Injury 773	Unintentional Injury 916	Unintentional Injury 12,458		Unintentional Injury 15,102	Malignant Neoplasms 50,616	Malignant Neoplasms 106,829	Heart Disease 479,150	Heart Disease 599,413
2	Short Gestation 4,538	Congenital Anomalies 464	Malignant Neoplasms 477	Malignant Neoplasms 419	Homicide 4,862	Suicide 5,320	Malignant Neoplasms 12,519	Heart Disease 36,927	Heart Disease 67,261	Malignant Neoplasms 391,035	Malignant Neoplasms 567,628
3	SIDS 2,226	Homicide 376	Congenital Anomalies 195	Suicide 259	Suicide 4,371	Homicide 4,222	Heart Disease 11,081	Unintentional Injury 19,974	Chronic Low. Respiratory Disease 14,160	Chronic Low Respiratory Disease 117,098	Chronic Low. Respiratory Disease 137,353
4	Maternal Pregnancy Comp. 1,608	Malignant Neoplasms 350	Homicide 119	Homicide 186	Malignant Neoplasms 1,636	Malignant Neoplasms 3,659	Suicide 6,677	Suicide 8,598	Unintentional Injury 12,933	Cerebro-vascular 109,238	Cerebro-vascular 128,842
5	Unintentional Injury 1,181	Heart Disease 154	Influenza & Pneumonia 106	Congenital Anomalies 169	Heart Disease 1,035	Heart Disease 3,174	Homicide 2,762	Liver Disease 8,377	Diabetes Mellitus 11,361	Alzheimer's Disease 78,168	Unintentional Injury 118,021
6	Placenta Cord. Membranes 1,064	Influenza & Pneumonia 146	Heart Disease 97	Influenza & Pneumonia 122	Congenital Anomalies 457	HIV 881	Liver Disease 2,481	Cerebro-vascular 6,163	Cerebro-vascular 10,523	Diabetes Mellitus 48,944	Alzheimer's Disease 79,003
7	Bacterial Sepsis 652	Septicemia 71	Chronic Low. Respiratory Disease 64	Heart Disease 120	Influenza & Pneumonia 418	Influenza & Pneumonia 807	HIV 2,425	Diabetes Mellitus 5,725	Liver Disease 9,154	Influenza & Pneumonia 43,469	Diabetes Mellitus 68,705
8	Respiratory Distress 595	Chronic Low. Respiratory Disease 66	Benign Neoplasms 40	Chronic Low. Respiratory Disease 59	Complicated Pregnancy 227	Diabetes Mellitus 604	Cerebro-vascular 1,916	Chronic Low. Respiratory Disease 4,664	Suicide 5,808	Nephritis 40,465	Influenza & Pneumonia 53,692
9	Circulatory System Disease 581	Perinatal Period 58	Septicemia 33	Benign Neoplasms 45	Cerebro-vascular 193	Cerebro-vascular 537	Diabetes Mellitus 1,872	HIV 3,388	Nephritis 4,792	Unintentional Injury 39,111	Nephritis 48,935
10	Neonatal Hemorrhage 517	Benign Neoplasms 53	Cerebro-vascular 32	Cerebro-vascular 42	Chronic Low. Respiratory Disease 187	Liver Disease 459	Influenza & Pneumonia 1,314	Influenza & Pneumonia 2,918	Septicemia 4,628	Septicemia 26,763	Suicide 36,909

Data Source: National Vital Statistics System, National Center for Health Statistics, CDC.

Produced by: Office of Statistics and Programming, National Center for Injury Prevention and Control, CDC using WISQARS™.



Centers for Disease Control and Prevention  
 National Center for Injury Prevention and Control

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Figure 1.1 Ten leading causes of death by age group. (From CDC Vital Statistics: <http://www.cdc.gov/Injury/wisqars/pdf/10LCD-Age-Grp-US-2009-a.pdf>.)<sup>2</sup>

injuries. Seatbelts and airbags have been shown to decrease mortality, but they can also cause significant injuries. Lap belts have been implicated in Chance fractures of the lumbar spine and perforations of hollow viscus organs, as well as in pancreatic injuries. Airbags can cause corneal, facial, and neck trauma.

### Motorcycle collisions

In 2010, within the United States, there were 4502 fatalities as a result of motorcycle collisions.<sup>6</sup> Motorcyclists are about 34 times more likely than passenger car occupants to die in a vehicular crash.<sup>6</sup> The potential for injury in a motorcycle collision is high because of the massive amount of energy transferred to the motorcyclist, who is then usually ejected from the bike, as well as because of the lack of protection from the vehicle itself. Motorcycle helmets are designed to reduce the direct force to the head and disperse it over the entire foam padding of the helmet. Helmets have been shown to decrease

risk of death by 37% and serious injury by 67%.<sup>8</sup> Despite the proven benefit of motorcycle helmets, only 19 states have mandatory helmet laws for riders of all ages.

Similar to motor vehicle crashes, motorcycle crash injury patterns depend on the location and speed of impact. Frontal impact with ejection can lead to injury to the head, chest, abdomen, or long bones. Lateral impact often results in closed and open fractures of the extremities. Soft tissue injuries and abrasions such as “road rash” are common in all impact patterns.

### Pedestrian struck

It is estimated that nearly two people for every 100,000 in the population will die as a result of being struck by a motor vehicle. Nearly 46% of pedestrian fatalities are alcohol-related either in the pedestrian or in the driver. January 1st and October 31st are the most common dates for being struck by a vehicle. Pedestrians are more likely to be killed between the

hours of 3 a.m. and 6 a.m. on Saturday or Sunday. Males are more likely to be struck than females. On average, a pedestrian is killed every 108 minutes and injured every eight minutes.<sup>9</sup>

The pattern of injury depends on the height of the person and the vehicle involved. A bumper impact to the lower

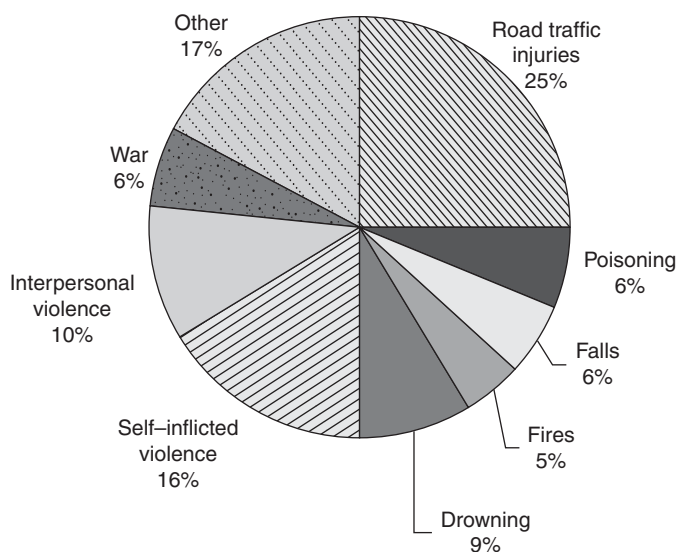
extremities results in closed and open fractures, knee dislocations, and pelvic fractures. Impact with the hood or windshield can cause head and torso injuries. Impact with the ground after being struck can cause head injuries and soft tissue injury (road rash). Children who are struck by a car are often knocked down and subsequently run over by the vehicle (see Chapters 34 and 35). This can result in an array of injuries to the torso, extremities, and head.

### Falls

In the United States, falls are the most common unintentional cause for nonfatal injuries. As our population continues to age, falls are becoming even more common (see Chapter 36). Elderly patients can sustain significant injury even with a low impact fall from standing. Medical comorbidities and medications such as anticoagulants and antiplatelet agents all contribute to elderly fall patient injuries. The Centers for Disease Control and Prevention (CDC) estimate that one in three adults over 65 years old fall each year. Older adults are hospitalized five times more often as a result of a fall than any other injury mechanism. In 2009, United States emergency departments treated 2.2 million elderly fall patients, with more than 582,000 of these requiring hospital admissions. Treatment costs for elderly fall patients are staggering. In 2000, over \$19 billion was spent treating falls in patients over 65 years old.<sup>10</sup>

Younger patients are more likely to fall from heights such as a ladder or scaffold while working. The median lethal distance for falls (LD50) is four stories or 48 feet (15 meters). This means that 50% of patients who fall four stories will die.

Distribution of global injury mortality by cause, 2000



**Figure 1.2** Distribution of global injury mortality by cause. (From Peden M, McGee K, Sharma G. *The injury Chart Book: a Graphical Overview of the Global Burden of Injuries*. Geneva: World Health Organization, 2002.<sup>3</sup>) A black and white version of this figure will appear in some formats. For the color version, please refer to the plate section.

**Number of Deaths and Estimated Average and Total Lifetime Costs Classified by Mechanism and Intent**  
 Costs Expressed in 2005 U.S. Prices

Death and Type of Cost			Intent			
			Unintentional	Suicide	Homicide	Total
Mechanism						
All Mechanisms	Deaths	–	117 809	32 637	18 124	168 570
	Medical Cost	Average	\$11 670	\$3 056	\$6 265	\$9 421
		Total	\$1 374 873 000	\$99 733 000	\$113 552 000	\$1 588 159 000
	Work Loss Cost	Average	\$890 723	\$1 058 114	\$1 390 878	\$976 907
		Total	\$104 935 229 000	\$34 533 683 000	\$25 208 272 000	\$164 677 183 000
	Combined Cost	Average	\$902 394	\$1 061 170	\$1 397 143	\$986 328
		Total	\$106 310 102 000	\$34 633 416 000	\$25 321 824 000	\$166 265 342 000

**Figure 1.3** 2005 economic burdens of unintentional and intentional (suicide and homicide) injuries. (From the Web-based Injury Statistics Query and Reporting System: <http://www.cdc.gov/injury/wisqars>.)<sup>4</sup>

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Mortality increases to 90% when the fall is seven stories.<sup>11</sup> In addition to height, other prognostic factors include the impact surface and which body part makes first contact.<sup>12</sup> Patients who land on their feet sustain injuries to the calcaneus, tibia, femoral neck, and spine. Both solid and/or hollow viscus injuries are also common. Fall victims who land on their back see significant spine, pulmonary, and cardiac injuries. Patients who land on their head may suffer significant brain and cervical spine injuries.

### Suicide

Suicide is a major public health concern. In 2009, suicide was the tenth most common cause of death within the United States, with 36,909 fatalities (Fig. 1.1). An estimated 11 suicide attempts occur for every suicide death.<sup>4</sup> Risk factors for suicide include depression and other mental disorders, substance abuse, family history of mental disorders, history of previous suicide attempts, history of family violence, and presence of firearms in the home. Firearms are involved in 54% of all suicides in the United States.<sup>13</sup> Significant money and research has been dedicated to suicide prevention. Suicide programs focus on modifying risk factors and treating the underlying mental and substance-abuse disorders.

### Homicide

In 2010, there were 12,996 murder victims in the United States. Seventy-seven percent of these were male, 50% were black, and 47% were white. Sixty-eight percent of the homicides included the use of a firearm, and 53% were conducted by someone the victim knew (family member, friend, acquaintance, significant other).<sup>14</sup> Unfortunately, homicide rates are not decreasing and homicide victims will continue to be a common patient population in trauma centers.

### Penetrating trauma

Injuries due to firearms and stab wounds continue to plague younger, inner-city, African-American males. As stated above, firearms are very common in both suicide and homicide. Nonfatal firearm injuries are also common. In 2004, there were 64,389 persons treated in American hospitals for nonfatal gunshot injuries.<sup>13</sup> Males comprised 89% of these nonfatal injuries. Over 1.2 billion healthcare dollars were spent treating these injuries. Eighty percent of this money was borne by the public because the injured patient was not insured.<sup>13</sup>

Firearm-related injuries are determined by several factors. One of the main factors is the velocity of the bullet. High-velocity bullets (rifles) compared to low-velocity bullets (hand-guns) tend to cause more injury because of the amount of kinetic energy within the moving projectile being transferred to the tissues. Individual bullet ballistics (full metal jacket, hollow points, soft points) and trajectory can also help predict

the injury severity. Blast injury away from the penetrating bullet must also be considered when evaluating a gunshot wound patient.

Although not as deadly as gunshot wounds, stab wounds carry a mortality of 1.5%. Stab wounds produce damage locally by blunt force and sharp cutting edges. Surrounding tissue damage is minimal. In 2007, approximately 2600 Americans died from violence-related stab wounds.<sup>8</sup>

### Burn wounds

Burns remain a common traumatic injury, often requiring the extensive care of a dedicated burn unit (see Chapters 39 and 40). Most victims of fires die from smoke and toxic gas inhalation rather than from burns. Cigarette smoking remains a common cause of fire-related deaths, and cooking is the primary cause of residential house fires. In 2011, an estimated 450,000 burn patients received medical attention in the United States, with 45,000 requiring admission, and 3500 died. Forty-four percent of these burns were from flame and 33% were scalds. In 2005, burn injuries and deaths cost approximately \$4 billion.<sup>15</sup>

### Summary

Trauma should be viewed as a disease rather than a random accidental event. Traumatic injury continues to be the leading cause of death in patients aged 1–44. Worldwide, injury is responsible for 9% of deaths. Injuries also create a significant financial burden due to direct costs as well as the loss of productivity and wages from the permanently injured or deceased patient. Traumatic injuries can be broken down into unintentional (e.g., motor vehicle collisions, falls) and intentional (suicide and homicide) mechanisms. Injury patterns within these various mechanisms depend on the kinetic energy absorbed by the body and the direction the energy travels through the body. Motor vehicle collisions are the most common mechanism for traumatic fatalities, and falls are the most common mechanism for nonfatal injuries. Suicide and homicide continue to be important mechanisms of trauma, accounting for 26% of global mortality. A basic understanding of the epidemiology of traumatic disease is imperative if we wish to decrease the burden of this illness through education, legislation, and research.

### Questions

- (1) True or false? In 2009, injury was the leading cause of death for people aged 1–44 years.
- (2) Which of the following is responsible for the greatest number of traumatic deaths?
  - a. Suicide
  - b. Firearm-related mortality
  - c. Motor vehicle collisions
  - d. Falls
- (3) Approximately what percentage of all fatal motor vehicle collisions involve alcohol consumption?

- a. 10%  
 b. 30%  
 c. 50%  
 d. 70%
- (4) In the United States, what is the most common cause of nonfatal injuries?  
 a. Suicide attempts  
 b. Motor vehicle collisions  
 c. Falls  
 d. Firearms
- (5) What is the median lethal distance for falls (i.e., the fall height at which 50% of patients will die)?  
 a. 1 story (12 feet)  
 b. 2 stories (24 feet)  
 c. 3 stories (36 feet)  
 d. 4 stories (48 feet)
- (6) Regarding suicide, which of the following is *false*?  
 a. In 2009, suicide was the tenth most common cause of death within the United States  
 b. Substance abuse is a risk factor for suicide  
 c. Firearms are involved in 80% of suicide attempts  
 d. There are 11 suicide attempts for every 1 suicide death
- (7) True or false? Females are more likely to be killed in a homicide-related death than males.
- (8) Which of the following are important considerations when determining injury patterns from firearm injuries?  
 a. Velocity of the bullet  
 b. Trajectory of the bullet  
 c. Individual bullet ballistics  
 d. All of the above
- (9) The mortality of stab wounds is approximately:  
 a. 1.5%  
 b. 5.5%  
 c. 10.5%  
 d. 25.5%
- (10) True or false? Most victims of fires die from smoke and toxic gas inhalation rather than from burns.

### Answers

- (1) True  
 (2) c  
 (3) b  
 (4) c  
 (5) d  
 (6) c  
 (7) False  
 (8) d  
 (9) a  
 (10) True

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## Section 1

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## Chapter

## 2

# Trauma in the prehospital environment and the emergency department

Sandra Werner

## Objectives

- (1) Describe the role of prehospital providers in the initial assessment/stabilization of trauma patients.
- (2) List criteria for initial patient transport to a trauma center versus non-trauma-center emergency department (ED).
- (3) Determine which patients in non-trauma-center EDs should be transferred to trauma centers.
- (4) Describe the initial assessment and resuscitation of trauma patients in the ED.
- (5) Discuss pain management and procedural sedation strategies for trauma patients in the ED.

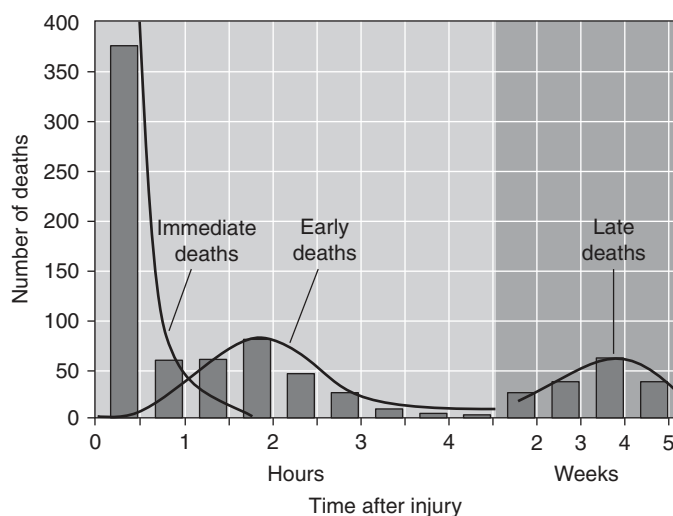
## Introduction

Injury mortality is classically described as having a trimodal distribution, with immediate deaths at the scene, early deaths due to airway obstruction and hemorrhage, and late deaths from organ failure. The second peak of trauma deaths occurs minutes to hours after the injury. Care given in the prehospital setting and in the emergency department (ED) is critical to reducing trauma mortality during this period (Fig. 2.1).

For most trauma victims, patient care commences with activation of the emergency medical services (EMS). Emergency medical responders are dispatched, arrive at the scene, and provide initial patient assessment and stabilization. Using protocols based on local and state trauma system requirements, patients are treated and transported to a local ED or trauma center.

Once in the ED, patients are reassessed and stabilized. Resuscitation measures are commenced or continued. For those trauma patients treated initially at freestanding EDs, or in EDs at smaller hospitals without the ability to provide trauma care, rapid transfer to a trauma center is usually indicated.

At the trauma center, patients are systematically reassessed in the ED by a dedicated trauma team. Airway management and initial resuscitation measures are continued, and the patient's further care is determined by the trauma team. Unstable patients requiring immediate surgical intervention go directly to the operating room (OR). However, most



**Figure 2.1** Graph demonstrating the three peaks of trauma deaths. (Reproduced with permission from American College of Surgeons. *Advanced Trauma Life Support, Student Manual*, 9th edition, 2012.<sup>1</sup>)

trauma patients will require imaging and consultation by specialty surgeons prior to disposition. Of the patients who do not require immediate operative intervention, some are admitted to the intensive care unit (ICU), some to the floor, and some are discharged to home. A number of patients will undergo additional procedures or imaging requiring sedation in the ED, or requiring transport and sedation in the interventional radiology suite.

This chapter provides an overview of prehospital and ED trauma patient assessment and management.

## Prehospital trauma care

### Historical perspective

The white paper *Accidental Death and Disability: the Neglected Disease of Modern Society*, written by the Committee on Trauma and Committee on Shock of the National Academy of Sciences in 1966, identified injury as the leading cause of death in young persons, and pointed out serious weaknesses in the American EMS system, including the fact that half of the

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nation's ambulance services were provided by morticians. The paper made 29 recommendations for improving prehospital care.<sup>2</sup>

In the same year, the 1966 Highway Safety Act established the foundation for the United States' modern emergency medical system.<sup>3</sup> The newly created Department of Transportation was given authority to improve EMS, including establishing standards of training for prehospital providers, development of regional EMS systems, and requirements for ambulance equipment. Training for prehospital providers today is based on standard curricula provided by the National Highway Administration. Prehospital care of the trauma patient is also based on guidelines developed by the American College of Surgeons (ACS) and taught in prehospital trauma life support courses.

EMS systems have evolved differently in other countries. In the US, prehospital care is provided nearly exclusively by emergency medical technicians (EMTs) and paramedics. In contrast, in the European model, physicians often make up part of the prehospital care team.

In the US, there are four levels of prehospital providers, first responder, EMT-basic, EMT-intermediate/advanced, and paramedic. Most ambulances are staffed primarily by EMTs or paramedics. Many rural EMS services are provided solely by volunteer basic EMTs. Most urban systems are staffed primarily by paramedics. A brief summary of the allowable scope of practice of EMTs versus paramedics is provided in Table 2.1.<sup>4</sup>

The exact scope of practice for prehospital providers is defined by a physician medical director, under whose license they practice. Advanced airway management and medication administration must be sanctioned by the medical director.

The goals of prehospital trauma care are the rapid assessment, stabilization, and transport of patients with potentially serious traumatic injuries to the appropriate trauma facility for definitive care. The steps of prehospital care are briefly outlined below.

### On-scene trauma care

In some cases, care of the trauma patient commences upon the arrival of EMS. However, there are often delays in the initiation of care due to scene safety and patient access issues. If a patient is accessible but requires extrication, resuscitative measures including basic airway intervention, hemorrhage control, immobilization, administration of fluids and pain medication, and prevention of hypothermia may be attempted.

Table 2.2 lists some of the causes of delay in reaching the trauma patient in common trauma scenarios.

Once the scene has been deemed safe and the patient has been reached, prehospital providers rapidly assess, provide critical interventions, and transfer the patient to an appropriate facility in accordance with prehospital trauma life support principles. Basic and advanced prehospital interventions are discussed below.

**Table 2.1** Basic emergency medical technician (EMT) and paramedic interventions

Intervention	Basic EMT	Additional paramedic interventions
Airway	Assessment Suction Bag valve mask ventilation Oral and nasal airway adjuncts Supplemental oxygen	Noninvasive positive-pressure ventilation Tracheal intubation Alternative airways Percutaneous cricothyroidotomy Needle chest decompression
Resuscitation	Hemorrhage control	IV access IO access IV fluid administration
Immobilization	Cervical collar Spinal immobilization Extremity and/or pelvic splinting Emergency patient moves	
Medications	Assist patient with own medications Administer oral glucose	Parenteral administration of ACLS medications, opioids, and antiepileptic medications, as well as anxiolytics RSI drugs in some cases
Defibrillation	Automated external defibrillation	Manual defibrillation 12-lead ECG acquisition Cardioversion Pacing

ACLS, advanced cardiac life support; ECG, electrocardiogram; IO, intraosseous; IV, intravenous; RSI, rapid sequence induction/intubation.

### Airway

Prehospital providers initiate basic airway measures, including oxygenation and ventilation, suction, and oral/nasal airways as needed (see Chapter 3). In-line stabilization of the cervical spine is maintained when indicated. Prehospital providers may also perform life-saving measures including needle decompression of tension pneumothoraces, placement of chest seals for open pneumothoraces, and stabilization of flail chest segments.

Advanced airway management may be initiated in the prehospital environment. The current Eastern Association for the Surgery of Trauma (EAST) level 1 guidelines for emergency endotracheal intubation in trauma patients are listed in Table 2.3.<sup>5</sup>

Studies of prehospital trauma intubations have yielded mixed results. Some studies have reported very high success rates in prehospital intubations, especially when paralytics are routinely used.<sup>6,7</sup> An early study in 1997 demonstrated

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**Table 2.2** Factors contributing to delayed initiation of patient care in the field

Mechanism	Causes of delay
Motor vehicle collision	Fire Power wires/poles Prolonged vehicle extrication Location of vehicle in unsafe area Weather extremes
Falls in outdoor areas	Location of fall Accessing area Equipment set-up Specialty rescue teams Weather extremes
Industrial or construction injuries	Chemical contamination Physical/equipment hazards Need for specialized rescue equipment Weather extremes
Terrorist incident	Scene safety Secondary device Patient contamination
Mass casualty incidents	Multiple patient access Triage of multiple patients Availability of transportation resources Coordination of patient disposition

improved outcomes in patients with severe head injury intubated in the field,<sup>8</sup> but several other studies demonstrated increased mortality in moderately and severely head-injured patients intubated during the prehospital phase of care.<sup>9–11</sup> The single study using computed tomography (CT) criteria for determination of head injury found that there was no difference in outcome in patients with Glasgow Coma Scale score (GCS) < 8, head injury on CT, and intubation in the field or ED (see Chapter 35, Table 35.1 for GCS).<sup>12</sup> The only prospective study of prehospital intubations was done in the pediatric population and demonstrated no improvement in outcomes in trauma patients intubated in the field.<sup>13</sup>

All of these studies have significant limitations, and there is no conclusive evidence to recommend for or against prehospital trauma intubation. Systems with the highest success rates have in common stringent training and skill maintenance requirements, including live OR intubations.<sup>14</sup> Prehospital trauma airway protocols should include the use of rescue airways such as the King LT, laryngeal mask airway, or Combitube.

### Hemorrhage control

Uncontrolled hemorrhage is the second leading cause of death for civilian trauma and the leading cause of combat mortality.<sup>15</sup> Immediate identification and control of external hemorrhage is a major goal of prehospital trauma care.

**Table 2.3** Eastern Association for the Surgery of Trauma (EAST) level 1 indications for emergency tracheal intubation of the trauma patient

Airway obstruction
Hypoventilation
Persistent hypoxemia (SaO <sub>2</sub> < 90 despite supplemental oxygen)
Severe cognitive impairment (GCS ≤ 8)
Severe hemorrhagic shock
Cardiac Arrest

GCS, Glasgow Coma Scale (see Table 35.1); SaO<sub>2</sub>, oxygen saturation.

Basic hemorrhage control in the prehospital environment consists of application of direct pressure, use of pressure points, and application of pressure dressings. Hemorrhage control is also achieved through reduction of angulated fractures and binding of open-book pelvic fractures.

Tourniquet use in civilian EMS systems is not common, because of concerns of increased morbidity and mortality. However, recent combat studies have demonstrated that tourniquets have low morbidity and improve outcomes when applied early (see Chapter 38).<sup>16,17</sup> Current Prehospital Trauma Life Support treatment guidelines recommend tourniquet use prior to extrication and transport if direct pressure and a pressure dressing fail to control bleeding.<sup>18</sup> A number of commercially available pelvic binders exist for compression of open-book pelvic fractures.

### Resuscitation

Resuscitation measures initiated in the field depend on level of training and local protocols. Most trauma protocols currently call for initiation of two large-bore IVs and administration of crystalloid fluid (see Chapters 4 and 5). However, evidence is emerging that administration of crystalloid solely to maintain blood pressure (BP), particularly in penetrating trauma, may be harmful.<sup>19,20</sup> The most recent revision of the Advanced Trauma Life Support (ATLS) guidelines for prehospital treatment has reduced the amount of crystalloid to be infused from 2 L to 1 L.<sup>1</sup>

Current ATLS guidelines call for initial resuscitation with lactated Ringer's (LR) with 0.9% saline (NS) as an alternative.<sup>21</sup> However, many EMS systems use 0.9% NS exclusively, as it is compatible with medication administration and reduces costs associated with deploying two types of crystalloid.

Colloids are not generally administered in the prehospital environment. In addition, while the use of hypertonic saline (HTS) in early resuscitation showed initial promise, two large studies were stopped early due to lack of benefits, and the ninth-edition ATLS guidelines do not recommend HTS.<sup>1,21,22</sup>

Because of the strict storage and administration requirements, blood products are not commonly administered in the prehospital environment. However, a growing number of aeromedical transport services are carrying O negative blood, and a few carry plasma. Third-generation hemoglobin-based

oxygen carriers have been studied in the prehospital environment, but none has been shown to improve outcomes.<sup>23</sup>

### Immobilization

All prehospital providers are trained in spinal, pelvis, and extremity immobilization. Most blunt trauma patients will be fully immobilized with C-collar and long backboard for transport. Airway control is accomplished with manual in-line C-spine control. Patients arriving in the ED must be removed from long spine boards as soon as possible to prevent skin breakdown.

### Additional EMS interventions

History taking is critical in the prehospital phase of trauma care. EMTs or paramedics may be the only healthcare providers with the opportunity to obtain the patient's medical history, allergies, and medications in a deteriorating trauma patient.

In addition, prehospital providers obtain critical information about the mechanism of injury. In falls, this information may include the height of the fall, position of patient, and type of surface struck. For motor vehicle collisions (MVCs), critical information includes vehicle speed, vehicle damage, position of the patient in the vehicle, restraints, and if the patient was ejected. Many EMS units carry cameras and provide scene photos.

Pain management may be initiated in the prehospital environment. Paramedics may administer narcotics in accordance with local protocols, and many services carry morphine or fentanyl.

### Prehospital termination of efforts

The American College of Surgeons (ACS) Committee on Trauma (COT) and National Association of EMS Physicians (NAEMSP) developed a joint guideline for the withholding and terminating resuscitation in trauma patients who are in cardiopulmonary arrest (see Chapter 42, Table 42.4).<sup>24</sup> Most EMS systems have developed local protocols implementing these guidelines.

## Initial transport of the trauma patient

Prehospital providers must field triage patients for transport to the closest hospital or to a trauma center based on patient condition, mechanism of injury, distance, road and air conditions, and additional factors. The ACS COT, in conjunction with the Centers for Disease Control and Prevention (CDC), has developed guidelines to assist prehospital providers with these decisions. The 2011 prehospital guidelines for triage to a trauma center are provided in Figure 2.2.<sup>25</sup>

Patients may be transported by ground unit or by aeromedical services. In most urban areas, ground units transport directly to the nearest trauma center. For remote trauma, EMS may transport to the closest local hospital, where the patient can be stabilized before transport to a trauma center, or,

alternatively, the patient may be transported directly from the scene by an aeromedical transport team.

Aeromedical transport, particularly by helicopter, has become more common in the past 20 years. Helicopter medical crews are usually experienced paramedics and/or nurses, and sometimes a physician. Crews are often trained in advanced airway management, including rapid sequence induction/intubation (RSI) and cricothyroidotomy. They may be trained in tube thoracostomy, limited ultrasound, central line placement, and administration of blood products. A number of studies, including a recent very large retrospective study, have found that helicopter transport of trauma patients reduces mortality, except in cases of traumatic cardiac arrest.<sup>26,27</sup>

Aeromedical transport is both expensive and a limited resource. Determining the appropriateness of ground versus helicopter transportation of trauma patients should take into account logistical and patient conditions. Helicopter transport may be indicated when ground transport times are lengthy and when extrication times exceed 20 minutes. The NAEMSP guidelines for patient conditions warranting consideration of aeromedical transport are provided in Table 2.4.<sup>28</sup>

## Emergency department care

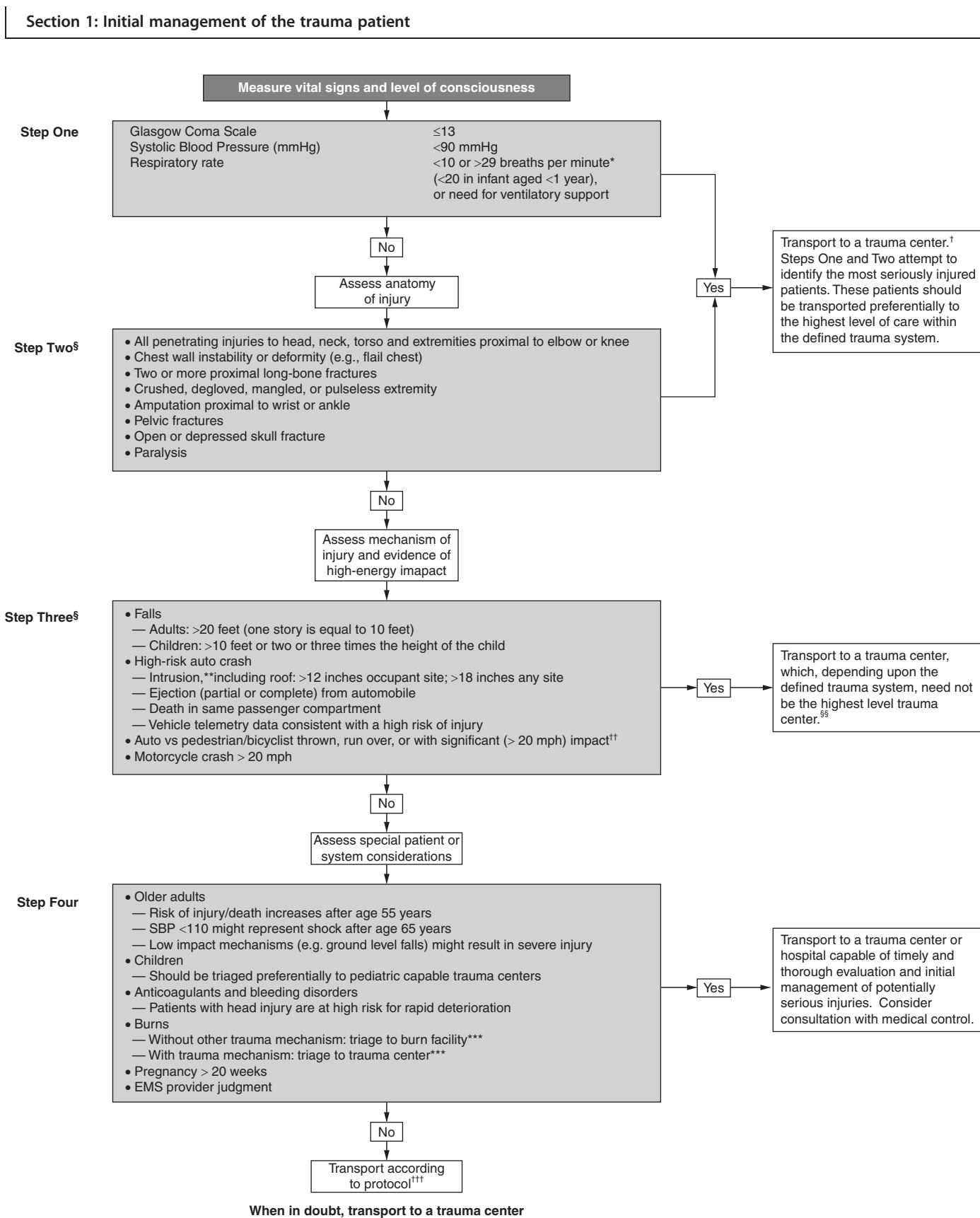
Trauma patients may initially be transported either to a trauma-center ED or to a non-trauma-center ED. Patients with minor trauma may be fully treated at non-trauma centers. However, in patients with significant traumatic injuries that have the potential to exceed the capabilities of the non-trauma hospital, expeditious transfer to a trauma center is indicated. One recent study found that mortality is improved with transfer to a Level I rather than Level II center.<sup>29</sup> The ACS COT criteria for inter-facility transfer are provided in Table 2.5.

Assessment and treatment of the trauma patient in non-trauma-center EDs should be guided by the principles of ATLS, with rapid assessment and stabilization, including essential airway, hemorrhage control, and resuscitative measures. For patients meeting trauma-center transfer criteria, imaging and laboratory studies should be minimized and should not delay transfer to the trauma center. The emergency physician (EP) at the outlying facility must communicate pertinent information, including exam findings and any interventions performed, to the receiving trauma center.

## Trauma-center emergency department initial assessment

Dedicated ED trauma teams are generally composed of trauma surgeons, anesthesiologists, EPs, and other surgical subspecialties, as well as nurses, technicians, and ancillary personnel. Many trauma centers are academic hospitals, and residents in emergency medicine, surgery, surgery subspecialties, and anesthesiology may make up the majority of the trauma team.

Advanced planning, preparation, and anticipation of patient conditions and injuries are critical to optimal



**Figure 2.2** Flow chart for prehospital trauma triage. (Reproduced with permission from the Centers for Disease Control and Prevention, 2012.<sup>25</sup>)