

Part 10.7: Cardiac Arrest Associated With Trauma

Basic and advanced life support for the trauma patient are fundamentally the same as that for the patient with a primary cardiac arrest, with focus on support of airway, breathing, and circulation. In trauma resuscitation providers perform the Primary Survey (called the initial assessment in the National Highway Traffic Safety Administration [NHTSA] EMS Curricula), with rapid evaluation and stabilization of the airway, breathing, and circulation. This is followed by the Secondary Survey (called the focused history and detailed physical examination in the NHTSA courses), which detects more subtle but potentially lethal injuries.

Cardiopulmonary deterioration associated with trauma has several possible causes:

- Hypoxia secondary to respiratory arrest, airway obstruction, large open pneumothorax, tracheobronchial injury, or thoracoabdominal injury
- Injury to vital structures, such as the heart, aorta, or pulmonary arteries
- Severe head injury with secondary cardiovascular collapse
- Underlying medical problems or other conditions that led to the injury, such as sudden cardiac arrest (eg, ventricular fibrillation [VF]) in the driver of a motor vehicle or in the victim of an electric shock)
- Diminished cardiac output or pulseless arrest (pulseless electrical activity [PEA]) from tension pneumothorax or pericardial tamponade
- Extreme blood loss leading to hypovolemia and diminished delivery of oxygen

Despite a rapid and effective out-of-hospital and trauma center response, patients with out-of-hospital cardiac arrest due to trauma rarely survive.^{1–4} Those patients with the best outcome from trauma arrest generally are young, have treatable penetrating injuries, have received early (out-of-hospital) endotracheal intubation, and undergo prompt transport (typically ≤ 10 minutes) to a trauma care facility.^{3–6} Cardiac arrest in the field due to blunt trauma is fatal in all age groups.^{7–9}

Extrication and Initial Evaluation

For years there has been a debate over whether ACLS providers should deploy a full armamentarium of interventions when treating victims of severe trauma at the scene. A number of studies have questioned the clinical effectiveness of on-site advanced airway management via endotracheal intubation as well as circulatory support with rapid intravenous (IV) infusions. The case against these interventions centers on 2 arguments: whether they are truly safe and

effective and whether they adversely delay transport to, and definitive management at, a hospital or emergency department (ED).

There is considerable evidence that out-of-hospital endotracheal intubation is either harmful or at best ineffective for most EMS patients.^{10–13} Researchers and emergency medical services (EMS) leaders have also questioned the safety and effectiveness of aggressive out-of-hospital IV fluid resuscitation in an urban environment.^{14–17} In addition, field ACLS interventions unquestionably prolong time at the scene, delay transport to the ED or trauma center, and thereby delay essential interventions, such as surgical control of life-threatening bleeding.^{17–20}

With the above discussion in mind, the focus of prehospital resuscitation should be to safely extricate and attempt to stabilize the patient and to minimize interventions that will delay transport to definitive care. Strict attention should be paid to stabilizing the spine during care. Patients suspected of having severe traumatic injuries should be transported or receive early transfer to a facility that can provide definitive trauma care. Attempts to stabilize the patient are typically performed during transport to avoid delay.

BLS for Cardiac Arrest Associated With Trauma

Airway

When multisystem trauma is present or trauma involves the head and neck, rescuers must stabilize the spine during all BLS maneuvers. A jaw thrust is used instead of a head tilt–chin lift to open the airway, with the priority to establish a patent airway. If at all possible, a second rescuer should be responsible for manually stabilizing the head and neck during BLS maneuvers and until spinal immobilization equipment is applied by trained providers. When the airway is open, clear the mouth of blood, vomitus, and other secretions.

Breathing/Ventilation

Once a patent airway is established, assess for breathing. If breathing is absent, agonal, or slow and extremely shallow, manual ventilation is needed. When ventilation is provided with a barrier device, a pocket mask, or a bag-mask device, the rescuer must still maintain cervical spine stabilization if cervical spine injury is suspected. Deliver breaths slowly to reduce risk of gastric inflation. If the chest does not expand during ventilation despite the presence of an adequate and patent airway, rule out tension pneumothorax or hemothorax.

Circulation

The provider should stop any visible hemorrhage using direct compression and appropriate dressings. After opening the airway and delivering 2 effective rescue breaths, the health-care provider should attempt to feel a carotid pulse. If the health-care provider does not definitely feel a pulse within 10 seconds, the provider should begin chest compressions and

(*Circulation*. 2005;112:IV-146-IV-149.)

© 2005 American Heart Association.

This special supplement to *Circulation* is freely available at <http://www.circulationaha.org>

DOI: 10.1161/CIRCULATIONAHA.105.166569

provide cycles of compressions and ventilations. During CPR, rescuers should provide compressions of adequate number and depth (rescuers should push hard and fast), allow full chest recoil after each compression, and minimize interruptions in chest compressions.

When CPR is provided for a victim with an advanced airway in place, 2 rescuers no longer deliver cycles of compressions interrupted with pauses for ventilation. Instead, the compressing rescuer should deliver 100 compressions per minute continuously, without pauses for ventilation. The rescuer delivering the ventilations should give 8 to 10 breaths per minute and should be careful to avoid delivering an excessive number of ventilations. The 2 rescuers should change compressor and ventilator roles approximately every 2 minutes to prevent compressor fatigue and deterioration in quality and rate of chest compressions. When multiple rescuers are present, they should rotate the compressor role about every 2 minutes.

If an automated external defibrillator (AED) is available, turn it on and attach it. The AED will evaluate the victim's cardiac rhythm and advise delivery of a shock if appropriate. If VF is present, note that the VF may have been the cause rather than the consequence of the trauma (eg, an automobile driver develops VF sudden cardiac arrest and when he loses consciousness he crashes the car). The victim may require further cardiac evaluation following resuscitation.

Disability

Throughout all interventions, assess the victim's response and monitor closely for signs of deterioration.

Exposure

To define the extent of injury, remove the victim's clothing. When the assessment for injuries is complete, cover the patient to prevent the development of hypothermia.

ACLS for Cardiac Arrest Associated With Trauma

ACLS includes continued assessment and support of the airway, oxygenation and ventilation (breathing), and circulation. Some of these procedures may be performed only after the patient has arrived at the hospital.

Airway

Indications for immediate intubation of the trauma patient include

- Respiratory arrest or apnea
- Respiratory failure, including severe hypoventilation or hypoxemia despite oxygen therapy
- Severe head injury (eg, Glasgow Coma Scale score [GCS] <8)
- Inability to protect the upper airway (eg, loss of gag reflex, depressed level of consciousness)
- Thoracic injuries (eg, flail chest, pulmonary contusion, penetrating trauma)
- Injuries associated with potential airway obstruction (eg, crushing facial or neck injuries)

Endotracheal intubation is performed while maintaining cervical spine stabilization. If intubation is performed in the field, it should be done during transport. Generally orotracheal intubation is performed. Avoid nasotracheal intubation in the presence of severe maxillofacial injuries. Confirm proper tube placement by clinical examination and use of a confirmation device (eg, an exhaled CO₂ monitor) immediately after intubation, during transport, and after any transfer of the patient (eg, from ambulance to hospital stretcher). Unsuccessful endotracheal intubation for the patient with massive facial injury and edema is an indication for cricothyrotomy by experienced providers.

When an endotracheal tube or other advanced airway is in place during CPR, simultaneous ventilations and compressions may result in a tension pneumothorax in an already damaged lung, especially if fractured ribs or a fractured sternum is present. Providers should suspect the development of a tension pneumothorax if there is a decrease in chest expansion and breath sounds, increased resistance to hand (bag-tube) ventilation, or if the patient's oxygen saturation falls.

Ventilation

Provide high inspired concentrations of oxygen even if the victim's oxygenation appears adequate. Once a patent airway is established, assess breath sounds and chest expansion. A unilateral decrease in breath sounds associated with inadequate chest expansion during positive-pressure ventilation should be presumed to be caused by *tension pneumothorax* or hemothorax until those complications can be ruled out. Healthcare providers will perform needle aspiration of the pneumothorax followed by insertion of a chest tube (this procedure typically is performed in the hospital).

Rescuers should look for and seal any significant open pneumothorax, allowing an exhalation port so that tension pneumothorax will not occur.

Hemothorax may also interfere with ventilation and chest expansion. Treat hemothorax with blood replacement and insertion of a chest tube, and check the initial volume of blood that comes out of the chest tube. Ongoing hemorrhage from the chest tube is an indication for surgical exploration.

Circulation

When the airway, oxygenation, and ventilation are adequate, evaluate and support circulation. Immediately control obvious visible bleeding. Volume resuscitation is an important but controversial part of trauma resuscitation. ACLS providers should establish large-bore IV access while en route to the ED or trauma center, limiting attempts to two. Isotonic crystalloid is the resuscitation fluid of choice because research has not clearly established any specific type of solution as superior.²¹ When replacement of blood loss is required in the hospital, it is accomplished with a combination of packed red blood cells and isotonic crystalloid.

Aggressive fluid resuscitation is not required for trauma patients who have no evidence of hemodynamic compromise. Recommendations for volume resuscitation in trauma patients with signs of hypovolemic shock are determined by the type of trauma (penetrating vs blunt) and the setting (urban vs

TABLE. Suggested Indications for Resuscitative Thoracotomy: Patients With Traumatic Cardiac Arrest

Type of Injury	Assessment
Blunt trauma	<ul style="list-style-type: none"> ● Patient arrives at ED or trauma center with pulse, blood pressure, and spontaneous respirations, <i>and</i> ● then experiences witnessed cardiac arrest
Penetrating cardiac trauma	<ul style="list-style-type: none"> ● Patient experiences a witnessed cardiac arrest in ED or trauma center <i>or</i> ● Patient arrives in ED or trauma center after <5 minutes of out-of-hospital CPR and with positive secondary signs of life (eg, pupillary reflexes, spontaneous movement, organized ECG activity)
Penetrating thoracic (noncardiac) trauma	<ul style="list-style-type: none"> ● Patient experiences a witnessed cardiac arrest in ED or trauma center <i>or</i> ● Patient arrives in ED or trauma center after <15 minutes of out-of-hospital CPR and with positive secondary signs of life (eg, pupillary reflexes, spontaneous movement, organized ECG activity)
Exsanguinating abdominal vascular trauma	<ul style="list-style-type: none"> ● Patient experiences a witnessed cardiac arrest in ED or trauma center <i>or</i> ● Patient arrives in ED or trauma center with positive secondary signs of life (eg, pupillary reflexes, spontaneous movement, organized ECG activity) <i>plus</i> ● Resources available for definitive repair of abdominal-vascular injuries

rural). A high rate of volume infusion with the therapeutic goal of a systolic blood pressure ≥ 100 mm Hg is now recommended only for patients with isolated head or extremity trauma, either blunt or penetrating. In the urban setting, aggressive prehospital volume resuscitation for penetrating trauma is no longer recommended because it is likely to increase blood pressure and consequently accelerate the rate of blood loss, delay arrival at the trauma center, and delay surgical intervention to repair or ligate bleeding vessels.^{4,14,22} Such delay cannot be justified when the patient can be delivered to a trauma center within a few minutes. In rural settings, transport times to trauma centers will be longer, so volume resuscitation for blunt or penetrating trauma is provided during transport to maintain a systolic blood pressure of 90 mm Hg.

As noted above, if pulseless arrest develops, outcome is poor unless a reversible cause can be immediately identified and treated. Successful trauma resuscitation often depends on restoration of an adequate circulating blood volume.

The most common terminal cardiac rhythms observed in victims of trauma are PEA, bradysystolic rhythms, and occasionally VF/ventricular tachycardia (VT). Treatment of PEA requires CPR and identification and treatment of reversible causes, such as severe hypovolemia, hypothermia, cardiac tamponade, or tension pneumothorax.²³ Development of bradysystolic rhythms often indicates the presence of severe hypovolemia, severe hypoxemia, or cardiorespiratory failure. VF and pulseless VT are treated with CPR and attempted defibrillation. Although epinephrine is typically administered during the ACLS treatment of these arrhythmias, it will likely be ineffective in the presence of uncorrected severe hypovolemia.

Since publication of the *ECC Guidelines 2000* several centers have reported their retrospective observations about resuscitative thoracotomies for patients in traumatic cardiac arrest.^{24–27} For example, one series reported 49 patients with

penetrating chest trauma who underwent resuscitative thoracotomy in the ED.²⁷ None of the patients in cardiac arrest or without signs of life *before* thoracotomy survived to hospital discharge.

In a 2002 report of resuscitative thoracotomies for trauma patients in the ED,²⁴ the 3 survivors of 10 victims of penetrating trauma all had signs of life and vital signs on arrival at the ED. In contrast, all 19 patients with blunt trauma died, despite the fact that 14 of the 19 “had vital signs” at the time of the thoracotomy. In a database of 959 resuscitative thoracotomies,²⁶ 22 victims of penetrating trauma and 4 victims of blunt trauma survived to hospital discharge after receiving prehospital CPR (overall survival rate of 3%).

In 2001 the Committee on Trauma of the American College of Surgeons published a systematic review of 42 studies of ED thoracotomies involving nearly 7000 patients, published from 1966 to 1999.²⁸ In this database, survival was 11% (500 of 4482) for victims of penetrating trauma and 1.6% (35 of 2193) for victims of blunt trauma.

These studies suggest that there may be a role for open thoracotomy in specific patients or situations. The Table describes conditions under which an open thoracotomy may be considered. Open thoracotomy does not improve outcome from out-of-hospital blunt trauma arrest but can be lifesaving for patients with penetrating chest trauma if the patient has an arrest immediately before arrival at the ED or while in the ED. During concurrent volume resuscitation for penetrating trauma, prompt emergency thoracotomy will permit direct massage of the heart, relief of cardiac tamponade, control of thoracic and extrathoracic hemorrhage, and aortic cross-clamping.^{2,4} This procedure should be performed only by experienced providers.

Cardiac contusions causing significant arrhythmias or impaired cardiac function are present in approximately 10% to 20% of victims of severe blunt chest trauma.²⁹ Myocardial contusion should be suspected if the trauma victim has

extreme tachycardia, arrhythmias, and ST–T-wave changes. Cardiac biomarkers (see Part 8: “Stabilization of the Patient With Acute Coronary Syndromes”) are not sensitive indicators of cardiac contusion.³⁰ The diagnosis of myocardial contusion is confirmed by echocardiography or radionuclide angiography.

Transfer

If a patient arrives at a facility with limited trauma capability, hospital staff should treat identifiable and reversible injuries to their capability. The patient should then be rapidly transferred to a facility that can provide definitive trauma care.

References

1. Pepe PE. Emergency medical services systems and prehospital management of patients requiring critical care. In: Carlson R, Geheb M, eds. *Principles and Practice of Medical Intensive Care*. Philadelphia, Pa: WB Saunders Co; 1993:9–24.
2. Rozycki GS, Adams C, Champion HR, Kihn R. Resuscitative thoracotomy—trends in outcome [abstract]. *Ann Emerg Med*. 1990;19:462.
3. Copass MK, Oreskovich MR, Bladergroen MR, Carrico CJ. Prehospital cardiopulmonary resuscitation of the critically injured patient. *Am J Surg*. 1984;148:20–26.
4. Durham LA III, Richardson RJ, Wall MJ Jr, Pepe PE, Mattox KL. Emergency center thoracotomy: impact of prehospital resuscitation. *J Trauma*. 1992;32:775–779.
5. Kloeck W. Prehospital advanced CPR in the trauma patient. *Trauma Emerg Med*. 1993;10:772–776.
6. Schmidt U, Frame SB, Nerlich ML, Rowe DW, Enderson BL, Maull KI, Tscherne H. On-scene helicopter transport of patients with multiple injuries—comparison of a German and an American system. *J Trauma*. 1992;33:548–553.
7. Rosemurgy AS, Norris PA, Olson SM, Hurst JM, Albrink MH. Prehospital traumatic cardiac arrest: the cost of futility. *J Trauma*. 1993;35:468–473.
8. Bouillon B, Walther T, Kramer M, Neugebauer E. Trauma and circulatory arrest: 224 preclinical resuscitations in Cologne in 1987–1990 [in German]. *Anaesthesist*. 1994;43:786–790.
9. Hazinski MF, Chahine AA, Holcomb GW III, Morris JA Jr. Outcome of cardiovascular collapse in pediatric blunt trauma. *Ann Emerg Med*. 1994;23:1229–1235.
10. Cummins RO, Hazinski MF. Guidelines based on the principle ‘First, do no harm’: new guidelines on tracheal tube confirmation and prevention of dislodgment. *Resuscitation*. 2000;46:443–447.
11. Katz SH, Falk JL. Misplaced endotracheal tubes by paramedics in an urban emergency medical services system. *Ann Emerg Med*. 2001;37:32–37.
12. Gausche M, Lewis RJ, Stratton SJ, Haynes BE, Gunter CS, Goodrich SM, Poore PD, McCollough MD, Henderson DP, Pratt FD, Seidel JS. Effect of out-of-hospital pediatric endotracheal intubation on survival and neurological outcome: a controlled clinical trial. *JAMA*. 2000;283:783–790.
13. Dutton RP, Mackenzie CF, Scalea TM. Hypotensive resuscitation during active hemorrhage: impact on in-hospital mortality. *J Trauma*. 2002;52:1141–1146.
14. Bickell WH, Wall MJ Jr, Pepe PE, Martin RR, Ginger VF, Allen MK, Mattox KL. Immediate versus delayed fluid resuscitation for hypotensive patients with penetrating torso injuries. *N Engl J Med*. 1994;331:1105–1109.
15. Dretzke J, Sandercock J, Bayliss S, Burls A. Clinical effectiveness and cost-effectiveness of prehospital intravenous fluids in trauma patients. *Health Technol Assess*. 2004;8:iii-1–iii-103.
16. Dula DJ, Wood GC, Rejmer AR, Starr M, Leicht M. Use of prehospital fluids in hypotensive blunt trauma patients. *Prehosp Emerg Care*. 2002;6:417–420.
17. Greaves I, Porter KM, Revell MP. Fluid resuscitation in pre-hospital trauma care: a consensus view. *J R Coll Surg Edinb*. 2002;47:451–457.
18. Koenig KL. Quo vadis: “scoop and run,” “stay and treat,” or “treat and street”? *Acad Emerg Med*. 1995;2:477–479.
19. Deakin CD, Allt-Graham J. Pre-hospital management of trauma patients: field stabilisation or scoop and run? *Clin Intensive Care*. 1993;4:24–27.
20. Nolan J. Advanced life support training. *Resuscitation*. 2001;50:9–11.
21. Moore FA, McKinley BA, Moore EE. The next generation in shock resuscitation. *Lancet*. 2004;363:1988–1996.
22. Solomonov E, Hirsh M, Yahiya A, Krausz MM. The effect of vigorous fluid resuscitation in uncontrolled hemorrhagic shock after massive splenic injury. *Crit Care Med*. 2000;28:749–754.
23. Kloeck WG. A practical approach to the aetiology of pulseless electrical activity: a simple 10-step training mnemonic. *Resuscitation*. 1995;30:157–159.
24. Grove CA, Lemmon G, Anderson G, McCarthy M. Emergency thoracotomy: appropriate use in the resuscitation of trauma patients. *Am Surg*. 2002;68:313–316; discussion 316.
25. Ladd AP, Gomez GA, Jacobson LE, Broadie TA, Scherer LR III, Solotkin KC. Emergency room thoracotomy: updated guidelines for a level I trauma center. *Am Surg*. 2002;68:421–424.
26. Powell DW, Moore EE, Cothren CC, Ciesla DJ, Burch JM, Moore JB, Johnson JL. Is emergency department resuscitative thoracotomy futile care for the critically injured patient requiring prehospital cardiopulmonary resuscitation? *J Am Coll Surg*. 2004;199:211–215.
27. Aihara R, Millham FH, Blansfield J, Hirsch EF. Emergency room thoracotomy for penetrating chest injury: effect of an institutional protocol. *J Trauma*. 2001;50:1027–1030.
28. Practice management guidelines for emergency department thoracotomy. Working Group, Ad Hoc Subcommittee on Outcomes, American College of Surgeons-Committee on Trauma. *J Am Coll Surg*. 2001;193:303–309.
29. McLean RF, Devitt JH, Dubbin J, McLellan BA. Incidence of abnormal RNA studies and dysrhythmias in patients with blunt chest trauma. *J Trauma*. 1991;31:968–970.
30. Paone RF, Peacock JB, Smith DL. Diagnosis of myocardial contusion. *South Med J*. 1993;86:867–870.

Part 10.7: Cardiac Arrest Associated With Trauma

Circulation. 2005;112:IV-146-IV-149; originally published online November 28, 2005;

doi: 10.1161/CIRCULATIONAHA.105.166569

Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231

Copyright © 2005 American Heart Association, Inc. All rights reserved.

Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the
World Wide Web at:

http://circ.ahajournals.org/content/112/24_suppl/IV-146

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in *Circulation* can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the [Permissions and Rights Question and Answer](#) document.

Reprints: Information about reprints can be found online at:
<http://www.lww.com/reprints>

Subscriptions: Information about subscribing to *Circulation* is online at:
<http://circ.ahajournals.org/subscriptions/>